DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

BULLETINS

Nos. 361-370

WASHINGTON

GOVERNMENT PRINTING OFFICE

1909

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 361

CENOZOIC MAMMAL HORIZONS OF WESTERN NORTH AMERICA

BY

HENRY FAIRFIELD OSBORN

WITH

FAUNAL LISTS OF THE TERTIARY MAMMALIA OF THE WEST

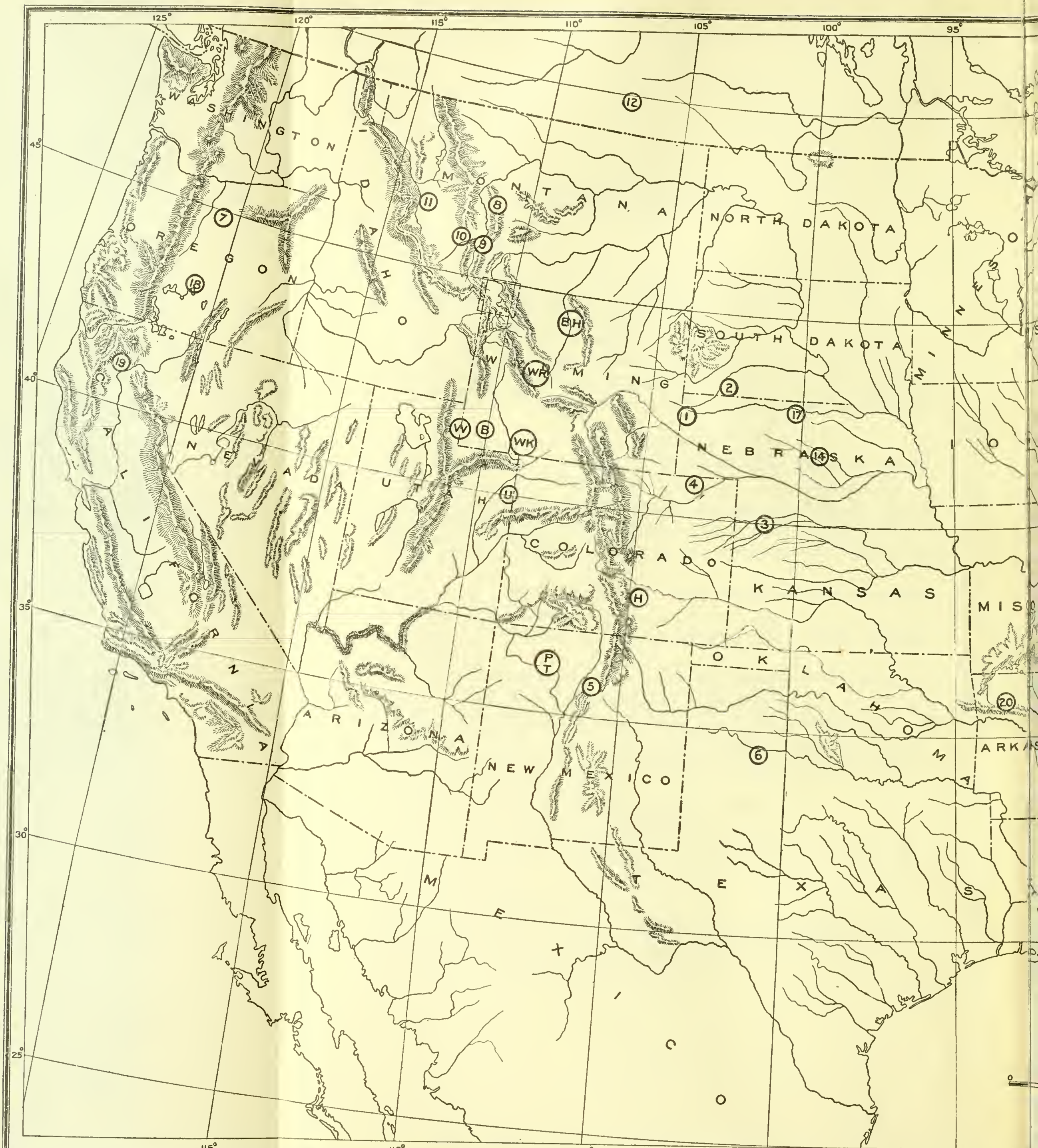
BY

WILLIAM DILLER MATTHEW

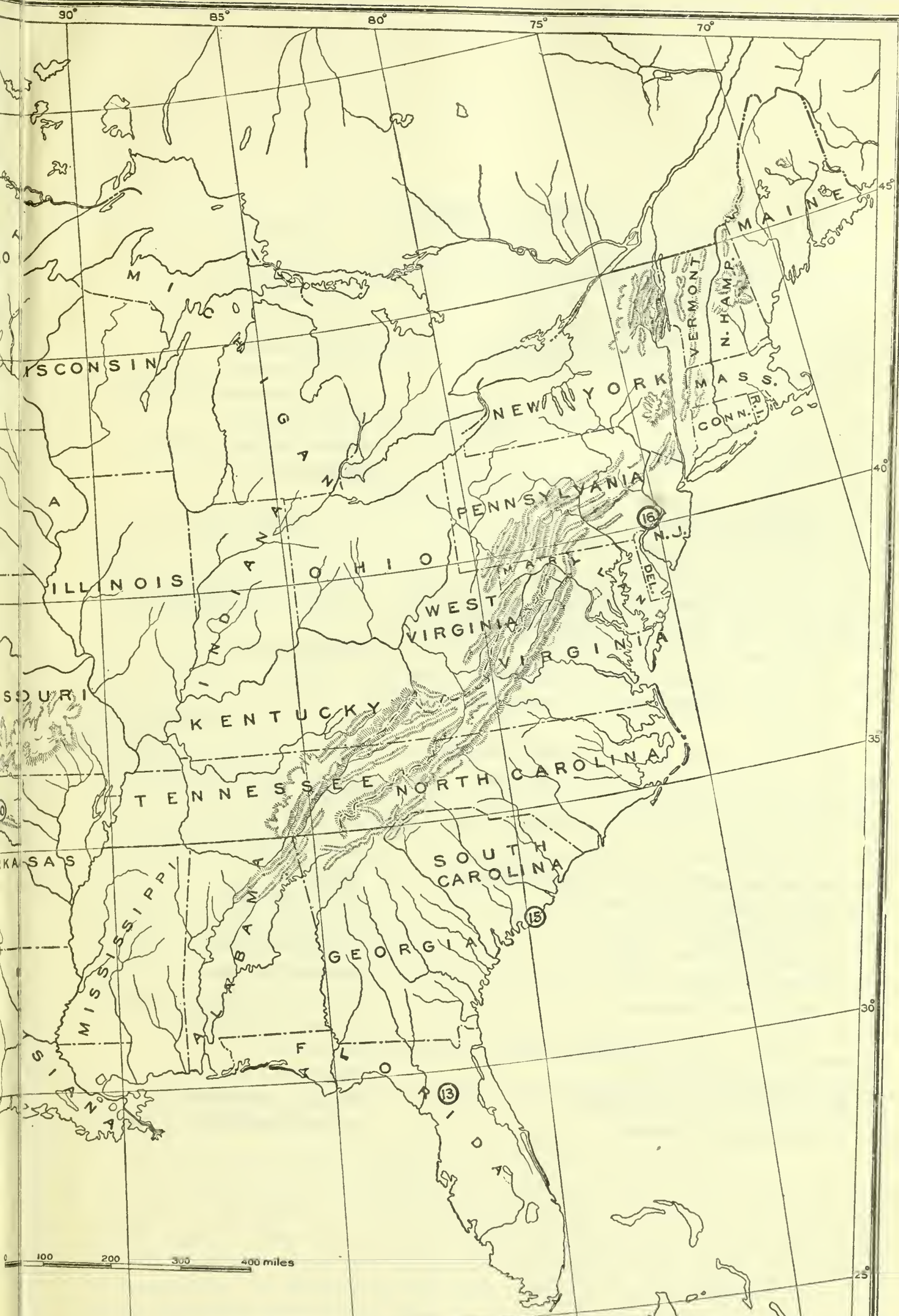
WASHINGTON
GOVERNMENT PRINTING OFFICE
1909

CONTENTS.

ILLUSTRATIONS.



MAP OF THE UNITED STATES, SHOWING THE GENERAL MOUNTAIN AND GREAT PLAINS REGIONS A
SECTIONS, AND DEPOSITS CONSIDERED IN



...ONS; ALSO THE TYPICAL LOCALITIES OF THE PRINCIPAL FORMATIONS,
...IN HIS PAPER.

KEY TO PLATE I.

PT—Puerco, Torrejon, and Wasatch of San Juan basin, New Mexico	Basal and lower Eocene.
BH—Wasatch of Bighorn Basin, Wyoming	Lower Eocene.
W—Wasatch (typical), Evanston, Wyoming	Lower Eocene.
WR—Wind River, Wyoming	Lower Eocene.
H—Huerfano, Colorado	Lower and middle Eocene.
B—Bridger, Wyoming	Middle Eocene.
WK—"Washakie," Wyoming	Middle and upper Eocene.
U—Uinta, Utah	Upper Eocene.
12—White River deposits along Swift Current Creek, Assiniboia, Canada	Lower Oligocene.
10—White River deposits along Pipestone Creek, Montana	Lower Oligocene.
2—Typical White River and Rosebud, South Dakota	Oligocene and Miocene.
1—White River, Monroe Creek, and Harrison, Nebraska	Oligocene and Miocene.
4—Pawnee Buttes section ("Pawnee Creek," "Martin Canyon," "Cedar Creek," "Horsetail Creek"), Colorado	Oligocene to middle Miocene.
7—John Day, Mascall, and Rattlesnake, Oregon	Oligocene, Miocene, and Pliocene.
8—"Fort Logan" and Deep River, Montana	Lower and middle Miocene.
11—"Flint Creek," Montana	Middle Miocene.
6—"Panhandle," "Clarendon," Blanco, and "Rock Creek," Texas	Miocene to Pleistocene.
17—"Nebraska" and underlying beds, Nebraska	Miocene.
5—"Santa Fe marls," New Mexico	Upper Miocene.
9—"Madison Valley," Montana	Upper Miocene.
3—"Republican River," Kansas	Lower Pliocene.
13—"Archer," Florida	Lower Pliocene.
14—"Loup River," Nebraska	Upper Pliocene.
18—Silver Lake, Oregon	Lower Pleistocene.
15—Ashley River, South Carolina	Pleistocene.
16—Port Kennedy, Pennsylvania	Middle Pleistocene.
19—Potter Creek cave, California	Middle Pleistocene.
20—Conard fissure, Arkansas	Upper Pleistocene.

CENOZOIC MAMMAL HORIZONS OF WESTERN NORTH AMERICA.

By Henry Fairfield Osborn.

INTRODUCTION.

FORMATIONS AND ZONES.

The main purpose of this paper is faunistic rather than geologic. Many of the geologic "groups" and "formations" referred to are still imperfectly defined and known, either as to geographic extent or as to lithologic content. Many of the geologic terms used are therefore not to be regarded as final. It should be clearly understood also that the geologic sections are largely diagrammatic and in most cases are not to be interpreted as giving a clue to the lithologic content.

LIFE ZONES.

It is proposed, according to the ruling of the International Geological Congress and the old practice of invertebrate paleontologists, to use the word "zone" for the faunistic levels of such geologic formations or groups as may be synchronized by the presence of certain distinctive animals. Thus we may speak of the *Uintatherium* zone of the upper Bridger formation or of the lower "Washakie." The word "beds," previously used in the same sense, is liable to cause confusion because it is used also for formations.

GEOLOGIC FORMATIONS.

A "formation" has been defined as follows by the United States Geological Survey:

In all classes of rocks the cartographic units shall be called formations.

The discrimination of sedimentary formations shall be based upon the local sequence of the rocks * * * and the geologist must select for the limitation of formations such horizons of change as will best express the geologic development and structure of the region and will give to the formations the greatest practical unity of constitution. In determining this unity of constitution all available lines of evidence, including paleontology, shall be considered. Each formation shall contain between its upper and lower limits either rocks of uniform character or rocks more or less uniformly varied in character as, for example, a rapid alternation of shale and limestone. * * * The definition of a formation * * * should include a

statement of the important facts which led to its discrimination and of the characteristics by which it may be identified in the field, whether by geologist or layman.

As uniform conditions of deposition were local as well as temporary, it is to be assumed that each formation is limited in horizontal extent. The formation should be recognized and should be called by the same name as far as it can be traced and identified by means of its lithologic character, its stratigraphic association, and its contained fossils.

The Survey has a committee on geologic names, which considers all questions of nomenclature that are raised by every paper offered for publication. The matter now stands as follows:

1. According to the ruling of the Survey all formations shall receive geographic names.

2. The necessity for this rule is demonstrated in the present review, because no two formations are found which are altogether coincident in time, although they may partly or very largely overlap in time.

3. Both formation and faunistic names are more or less subject to the law of priority of definition; but it is considered desirable by the committee on geologic names that certain names which are appropriate and have become well established in the literature should be retained, although their meanings may be preoccupied technically by other names which have not come into such general use.

CORRELATION.

The correlation of the Tertiary mammal horizons of western North America with those of Europe has engaged the attention especially of Cope (1879, 1884), Scott (1887), Clark (1891, 1896), Dall (1896, 1897), and Osborn (1897, 1898, 1900). As exact correlation appeared to be an essential for the writer's phylogenetic studies of the rhinoceroses and other groups, he published in 1897 a "Trial sheet of the typical and homotaxial horizons of Europe" as the basis of cooperation with various European geologists. Their kind criticisms and corrections were embodied in a "Second trial sheet" (1898) and in a "Third trial sheet" (1900).

In the years 1899 and 1900 the writer gave two addresses[a] before the New York Academy of Sciences, entitled "Correlation between Tertiary mammal horizons of Europe and America" and "Faunal relations of Europe and America during the Tertiary period and theory of the successive invasions of an African fauna into Europe." In 1899 Dr. W. D. Matthew published "A provisional classification of the fresh-water Tertiary of the West."[b] In June, 1905, there began in the Comptes Rendus a series of papers by Prof. Charles Depéret,

[a] Osborn, H. F., Correlation between Tertiary mammal horizons of Europe and America; an introduction to the more exact investigation of Tertiary zoogeography; preliminary study, with third trial sheet: Ann. New York Acad. Sci., vol. 13, No. 1, July 21, 1900, pp. 1-64.

Osborn, H. F., Corrélation des horizons de mammifères tertiaires en Europe et en Amérique: Compt. Rend. 8e Cong. géol. intern., 1900, pp. 357-363.

[b] Bull. Am. Mus. Nat. Hist., vol. 21, 1899, pp. 19-75.

entitled "L'évolution des mammifères tertiaires, méthodes et principes, importance des migrations,"[a] covering with fullness and precision the same subject of the Tertiary mammal succession of Europe and the migrations between the continents of Eurasia, North America, and Africa. For reasons fully set forth in the writer's correlation paper of 1899, he has adopted the faunistic subdivisions of France as classified by Depéret.

Taking renewed advantage of Professor Depéret's research and availing himself of the able cooperation of Doctor Matthew, the writer now outlines the methods and data of Tertiary correlation of the continental mountain and plains regions, and again treats the subject of migrations and American and European parallels from the standpoint of the remarkable American succession, which is now without a gap except in the Pliocene. The Pacific coast and Atlantic coast Tertiaries are not included in this review.

Many of the ideas are developments of those first expressed in the writer's correlation addresses above referred to and in his other addresses: "Rise of the Mammalia in North America" (1893),[b] and "Ten years' progress in mammalian paleontology" (1903).[c] A preliminary abstract of the present paper was published by permission of Director Walcott in March, 1907.[d]

BIBLIOGRAPHY OF WESTERN CENOZOIC HORIZONS AND THEIR CORRELATION.

The following bibliography contains only the most significant papers:

RECENT BIBLIOGRAPHY AND FORMATION NAMES.

Weeks, F. B. Bibliography of North American geology, paleontology, petrology, and mineralogy for the years 1892–1900, inclusive. U. S. Geol. Survey, Bulls. Nos. 188, 189, 1902.

——— North American geologic formation names. Bibliography, synonymy, and distribution. U. S. Geol. Survey Bull. No. 191, 1902.

——— Bibliography and index of North American geology, paleontology, petrology, and mineralogy for the years 1901–1905, inclusive. U. S. Geol. Survey, Bull. No. 301, 1906.

GENERAL CORRELATION OF TERTIARY HORIZONS.

Clark, W. B. Correlation papers—Eocene. The Eocene of the United States. U. S. Geol. Survey, Bull. No. 83, 1891, pp. 9–159.

Eocene of the Atlantic coast, Gulf States, Pacific coast; historical sketch of the Eocene of the interior. Table showing relative position of interior Eocene deposits. Map. Extensive bibliography.

[a] L'évolution des mammifères tertiaires. [1] Méthodes et principes: Compt. Rend. Acad. Sci. Paris, vol. 140 (June 5, 1905), p. 1517. [2] Réponse aux observations de M. Boule: Idem, vol. 141 (July 3, 1905), p. 22. [3] Importance des migrations: Idem, vol. 141 (Nov. 6, 1905), p. 703. [4] Importance des migrations: Idem, vol. 142 (Mar. 12, 1906), p. 618.

[b] Proc. Am. Assoc. Adv. Sci., 1894, pp. 188–277. Am. Jour. Sci., 3d ser., vol. 46, 1893, pp. 379–392, 448–446.

[c] Compt. Rend. 6e Cong. intern. de zoologie, 1904, pp. 86–113.

[d] Tertiary mammal horizons of North America: Bull. Am. Mus. Nat. Hist., vol. 23, art. 11, March 30, 1907, pp. 237–253.

COPE, E. D. The relations of the horizons of extinct Vertebrata of Europe and North America. U. S. Geol. and Geog. Survey Terr., Bull., vol. 5, No. 1, 1879.

Correlation of Mesozoic and Cenozoic horizons of Europe and North America.

——— The Vertebrata of the Tertiary formations of the West. Rept. U. S. Geol. Survey Terr., vol. 3, 1883 (1884). Section I.—The Tertiary formations of the central region of the United States. Section II.—The horizontal relations of the North American Tertiaries with those of Europe.

DALL, W. H. A table of the North American Tertiary horizons correlated with one another and with those of western Europe; with annotations. U. S. Geol. Survey, 18th Ann. Rept., 1896–97, pt. 2, 1898.

Marine Tertiary horizons of the Atlantic coast and of the Gulf States correlated with one another, with those of the Western States and those of western Europe.

DAWKINS, W. BOYD. The classification of the Tertiary period by means of the Mammalia. Quart. Jour. Geol. Soc., 1880, pp. 379–405.

Tertiary and Quaternary horizons and faunæ of Great Britain, France, and Italy correlated.

FILHOL, H. Observations sur le mémoire de M. Cope intitulé Rélations des horizons * * * d'animaux vertébrés fossiles en Europe et en Amérique. Ann. sci. géol., vol. 17, art. 5, 1885, pp. 1–18.

MARSH, O. C. Geologic horizons as determined by vertebrate fossils. Am. Jour. Sci., Oct., 1891, 3d ser., vol. 42, pp. 336–338.

——— Comparative value of different kinds of fossils in determining geological age. Am. Jour. Sci., Dec., 1898, 4th ser., vol. 6, pp. 483–486.

Value of a form depends upon its modifiability in accordance with changing conditions.

OSBORN, H. F. Correlation between Tertiary mammal horizons of Europe and America; an introduction to the more exact investigation of Tertiary zoogeography; preliminary study, with third trial sheet. New York Acad. Sci., Ann., vol. 13, 1900, pp. 1–64.

——— Corrélation des horizons de mammifères tertiaires en Europe et en Amérique. Compt. Rend. 8e Cong. géol. intern., 1900, pp. 357–363.

——— The geological and faunal relations of Europe and America during the Tertiary period and the theory of the successive invasions of an African fauna. Science, n. s., vol. 2, 1900, pp. 561–574.

Popular presentation of above-cited address.

GENERAL GEOLOGY AND FAUNÆ (NORTH AMERICA).

DAVIS, W. M. The fresh-water Tertiary formations of the Rocky Mountain region. Am. Acad. Arts and Sci., Proc., vol. 35, 1900, pp. 346–373.

History of opinion on mode of formation; evidence against lake-bed hypothesis and in favor of fluviatile origin.

GILBERT, G. K. The underground waters of the Arkansas Valley in eastern Colorado. U. S. Geol. Survey, 17th Ann. Rept., pt. 2, 1896, pp. 553–601.

Rocky Mountain deposits may be of fluviatile and not of lacustrine origin.

JOHNSON, W. D. The High Plains and their utilization. U. S. Geol. Survey, 21st Ann. Rept., pt. 4, 1901, pp. 601–741; 22d Ann. Rept., pt. 4, 1902, pp. 631–669.

Tertiary deposits of the plains, of fluviatile and flood-plain origin.

MARSH, O. C. Ancient lake basins of the Rocky Mountain region. Am. Jour. Sci., Jan., 1875, 3d ser., vol. 9, pp. 49–52.

——— Introduction and succession of vertebrate life in America. Am. Jour. Sci., 3d ser., vol. 9, 1877, pp. 337–378.

Plate showing successive horizons named from characteristic genera.

MATTHEW, W. D. A provisional classification of the fresh-water Tertiary of the West. Am. Mus. Nat. Hist., Bull., vol. 12, 1899, pp. 19–77.

Divisions of the Tertiary lake basins; fossiliferous horizons of the Great Plains; extensive faunal lists.

OSBORN, H. F. Ten years' progress in the mammalian paleontology of North America. Compt. Rend. 6e Cong. intern. de zoologie, session de Berne, 1904, pp. 86–113. Reprinted without the plates in Am. Geologist, vol. 36, 1905, pp. 199–229.

A summary. New phylogenetic problems. Review of the successive faunæ. Extensive references.

WORTMAN, J. L. Studies of Eocene Mammalia in the Marsh collection, Peabody Museum. Pt. II, Primates. Am. Jour. Sci., June, 1903, vol. 15, pp. 419–436.

European and American early Tertiary faunæ and floræ, probably derived from temperate Arctic land mass.

EOCENE.

COPE, E. D. The badlands of Wind River and their fauna. Am. Naturalist, vol. 14, 1880, pp. 745–748.

Eocene.

DARTON, N. H. Geology of the Bighorn Mountains. U. S. Geol. Survey, Prof. Paper No. 51, 1906.

See especially Bridger [i. e., Wind River] formation, p. 70.

DOUGLASS, EARL. The discovery of Torrejon mammals in Montana. Science, n. s., vol. 15, 1902, pp. 272–273.

——— A Cretaceous and lower Tertiary section in south-central Montana. Am. Philos. Soc., Proc., vol. 41, 1902, pp. 207–224.

Sketch of the Jurassic and Cretaceous deposits. Probable relations of the Laramie and overlying beds. Fossil mammals of the Fort Union beds.

EARLE, CHARLES. See OSBORN, H. F., and EARLE, CHARLES.

HAY, O. P. The fossil turtles of the Bridger basin. Am. Geologist, vol. 35, June, 1905, pp. 327-342.

Evidence showing that the Bridger basin is of flood-plain, not lacustrine origin.

HILLS, R. C. Recently discovered Tertiary beds of the Huerfano basin, Denver, 1888.

——— Additional notes on the Huerfano beds. Colorado Sci. Soc., Proc., Oct. 7, 1889.

——— Remarks on the classification of the Huerfano Eocene. Colorado Sci. Soc., Proc., vol. 4, 1891, pp. 7–9.

HAYDEN, F. V. Geological report of the exploration of the Yellowstone and Missouri rivers, by F. V. Hayden, assistant to Col. William F. Raynolds, U. S. Engineers, Washington, 1869.

——— Preliminary field report of the United States Geological Survey of Colorado and New Mexico (separate), Washington, 1869.

Bridger group, type description, p. 91.

LOOMIS, F. B. Origin of the Wasatch deposits. Am. Jour. Sci., May, 1907 4th ser., vol. 23, pp. 356–364.

Analysis of the fauna, of the stratigraphy, and of the petrography disproves lake-bed hypothesis and supports flood-plain hypothesis of the origin of the deposits. Detailed section. *Lambdotherium primævum* sp. nov., *Glyptosaurus obtusidens* sp. nov.

MATTHEW, W. D. A revision of the Puerco fauna. Am. Mus. Nat. Hist., Bull., vol. 9, 1897, pp. 259–323.

Faunal distinctiveness of the Puerco and Torrejon.

McMaster, J. B. Stratigraphical report upon the Bridger beds in the Washakie basin, Wyoming Territory, accompanied by profiles of three sections. In Osborn, H. F., A memoir upon *Loxolophodon* and *Uintatherium* . . . E. M. Mus. Geol. Archæol. Princeton, etc., Contr., 4°, vol. 1, No. 1, 1881.

Washakie formation.

Osborn, H. F. A memoir upon *Loxolophodon* and *Uintatherium*. E. M. Mus. Geol. Archæol. Princeton, etc., Contr., vol. 1, No. 1, 1881.

'Washakie' more recent than Bridger formation.

——— The Perissodactyla. Part III of Scott, W. B., and Osborn, H. F., The Mammalia of the Uinta formation. Am. Philos. Soc., Trans., n. s., vol. 16, pt. 3, Aug. 20, 1889, pp. 505–530.

——— Fossil mammals of the Uinta Basin; Expedition of 1894. Am. Mus. Nat. Hist., Bull., vol. 7, 1895, pp. 71–105.

Geology of the Uinta Basin; the three faunal levels (horizons A, B, C). with faunal lists. New genera and species, especially of *Mesonyx, Telmatherium, Sphenocœlus,* and *Elotherium.*

——— The Huerfano lake basin, southern Colorado, and its Wind River and Bridger fauna. Am. Mus. Nat. Hist., Bull., vol. 9, 1897, pp. 247–258.

Stratigraphy; analysis of Hill's report; faunal division into a lower horizon of Wind River age and an upper horizon of Bridger age.

——— and Earle, Charles. Fossil mammals of the Puerco beds; collection of 1892. Am. Mus. Nat. Hist., Bull., vol. 7, 1895, pp. 1–70.

Notes on the geology (Wortman). Analysis and description of the fauna.

——— and Wortman, J. L. Fossil mammals of the Wahsatch and Wind River beds; collection of 1891. Am. Mus. Nat. Hist., Bull., vol. 4, 1892, pp. 81–147

Geology of the Bighorn Basin (Wortman), p. 135; analysis and description of the fauna (Osborn).

Scott, W. B. The upper Eocene lacustrine formations of the West. Am. Assoc. Adv. Sci., Proc., 1887 (1888), p. 217. Abstract.

——— The upper Eocene lacustrine formations of the United States. Am. Assoc. Adv. Sci., Proc., vol. 36, 1887, pp. 217–218.

——— The geological and faunal relations of the Uinta formation. Pt. I of Scott, W. B., and Osborn, H. F., The Mammalia of the Uinta formation. Am. Philos. Soc., Trans., n. s., vol. 16, pt. 2, Aug. 20, 1889, pp. 462–470.

——— The selenodont artiodactyls of the Uinta Eocene. Wagner Free Inst. Sci., Trans., vol. 6, 1899, pp. i–xiii, 15–122, pls. 1–4.

Angular unconformity between horizons B and C. White River beds homotaxial with Ronzon of France (vide Hatcher). Uinta compared with Paris gypsum (Lutétien), i. e. lower Oligocene [upper Eocene].

Sinclair, W. J. Volcanic ash in the Bridger beds of Wyoming. Am. Mus. Nat. Hist., Bull. 22, 1906, pp. 273–280.

General features of the geology. Lithologic and stratigraphic classification of the Bridger group.

Veatch, A. C. Geography and geology of a portion of southwestern Wyoming, with special reference to coal and oil. U. S. Geol. Survey, Prof. Paper No. 56, 1907.

Deposits of the period between the known Cretaceous and the known Eocene; Evanston formation (Eocene?), p. 86; Wasatch group, pp. 87–96; Green River formation, p. 97; Bridger formation, p. 99.

WORTMAN, J. L. Geological and geographical sketch of the Bighorn Basin. In Osborn, H. F., and Wortman, J. L., Fossil mammals of the Wahsatch and Wind River beds. Am. Mus. Nat. Hist., Bull., vol. 4, 1892, pp. 135–144.

Wind River beds distinct from and successive to the Wasatch of Bighorn Basin.

——— and OSBORN, H. F. See OSBORN, H. F., and WORTMAN, J. L.

OLIGOCENE, MIOCENE, PLIOCENE.

COCKERELL, T. D. A. The fossil fauna and flora of the Florissant (Colorado) shales. Univ. Colorado, Studies, vol. 3, 1906, Boulder, Colo., pp. 157–176.

Birds, fishes, insects, mollusks, plants.

COPE, E. D. Observations on the faunæ of the Miocene Tertiaries of Oregon. U. S. Geol. and Geog. Survey Terr., Bull., vol. 5, 1879–80, pp. 55–69.

John Day (Oligocene).

——— Second contribution to a knowledge of the Miocene fauna of Oregon. Am. Philos. Soc., Proc., vol. 18, 1879, pp. 370–376.

John Day (Oligocene).

——— The White River beds of Swift Current River, Northwest Territory. Am. Naturalist, vol. 19, 1885, p. 163.

Oligocene, White River.

——— The Vertebrata of the Swift Current Creek region of the Cypress Hills. Geol. and Nat. Hist. Survey Canada, Ann. Rept., vol. 1, 1885 (1886), appendix to Article C, pp. 79–85.

Oligocene.

——— A preliminary report on the vertebrate paleontology of the Llano Estacado. Geol. Survey Texas, 4th Ann. Rept., 1892 (1893), pp. 1-136.

Description of the vertebrate fauna of the Loup Fork beds of the Llano Estacado, Texas.

CUMMINS, W. F. Notes on the geology of northwest Texas. Geol. Survey Texas, 3d Ann. Rept., 1891 (1892), pp. 129–200; 4th Ann. Rept., 1892 (1893), pp. 179–238.

Geology of the Llano Estacado.

DALL, W. H. Age of the Peace Creek bone beds of Florida. Acad. Nat. Sci. Philadelphia, Proc., 1891, p. 121.

Included in Pliocene.

——— Geological results of the study of the Tertiary fauna of Florida, 1886–1903. Wagner Free Inst. of Science, Philadelphia, Trans., vol. 3, pt. 6, 1903, pp. 1541-1620.

Oligocene and later formations. Tertiary Mollusca.

——— and HARRIS, G. D. Correlation papers. The Neocene of North America. U. S. Geol. Survey, Bull. No. 84, 1892.

See especially Chapter VI, on the supposed Neocene of the interior region, considered by States, pp. 280-317. Table showing the vertical range of the Neocene of the interior. Map, p. 178. List of names applied to Cenozoic beds and formations of the United States, p. 320.

DARTON, N. H. Preliminary report on the geology and underground-water resources of the central Great Plains. U. S. Geol. Survey, Prof. Paper No. 32, Washington, 1905.

See especially Chadron (*Titanotherium*), Brule (*Oreodon*), Arikaree, Ogalalla formations.

DARTON, N. H. Age of the Monument Creek formation. Am. Jour. Sci., Sept., 1905, 4th ser., vol. 20, pp. 178–180.

Titanotherium remains. Oligocene.

——— Geology and underground waters of the Arkansas Valley in eastern Colorado, U. S. Geol. Survey, Prof. Paper No. 52, 1906.

Monument Creek formation, containing *Titanotherium* of White River age, p. 34; Nussbaum formation, of late Tertiary age, p. 34.

DOUGLASS, EARL. The Neocene lake beds of western Montana, and descriptions of some new vertebrates from the Loup Fork. Univ. Montana, thesis, June, 1899.

Geology, faunæ, and correlation of White River, Deep River, and Madison Valley; Loup Fork horizons in Montana; systematic description of certain fossil camels, etc.

——— Fossil Mammalia of the White River beds of Montana. Am. Philos. Soc., Trans., n. s., vol. 20, 1901, pp. 1–42, pl. ix.

Pipestone beds, Toston beds, Blacktail Deer Creek beds. Geology and faunæ; new genera and species of mammals.

——— New vertebrates from the Montana Tertiary. Carnegie Mus. (Pittsburg, Pa.), Ann., vol. 2, No. 2, 1903, pp. 145–200.

Sage Creek beds (?Eocene), White River deposits, Fort Logan beds (upper Oligocene), Deep River and Flint Creek beds. New mammals described.

——— The Tertiary of Montana. Carnegie Mus. (Pittsburg, Pa.), Mem., vol. 2, 1905, pp. 203–224.

Chiefly a description of *Ictops*, *Xenotherium*, and other lower White River mammals.

GIDLEY, J. W. The fresh-water Tertiary of northwestern Texas, American Museum Expedition of 1899–1901. Am. Mus. Nat. Hist., Bull., vol. 19, 1903, pp. 617–635.

Geologic notes and sections; new mammals described. Rock Creek beds = Sheridan (*Equus*) beds (Pleistocene); Blanco beds (Pliocene); sections (1) at Mount Blanco of (?) Goodnight (Paloduro) Miocene, (2) showing Panhandle (lower or middle Miocene) beds, and (3) of Clarendon (Loup Fork) and Panhandle. Maps, faunæ.

——— See MATTHEW, W. D., and GIDLEY, J. W.

GILBERT, G. K. Lake Bonneville. U. S. Geol. Survey, Mon., vol. 1, 1890.

The age of the *Equus* fauna, p. 393. Faunally later than upper Pliocene of Arno Valley, and earlier than mid-Pleistocene, but surviving in Lake Bonneville region into middle or upper Pleistocene.

HARRIS, G. D. See DALL, W. H., and HARRIS, G. D.

HATCHER, J. B. Discovery of *Diceratherium*, the two-horned rhinoceros, in the White River beds of South Dakota. Am. Geologist, vol. 13, 1894, pp. 360–361.

Top of White River correlated with John Day formation.

——— On a small collection of vertebrate fossils from the Loup Fork beds of northwestern Nebraska; with note on the geology of the region. Am. Naturalist, vol. 28, 1894, pp. 236–248.

Ælurodon, *Aphelops*, *Teleoceras*, Loup Fork and *Equus* beds.

——— The *Titanotherium* beds. Am. Naturalist, Mar. 1, 1893, pp. 204–221.

Geographic distribution, description, stratigraphy; faunistic division into lower, middle, and upper beds.

——— Origin of the Oligocene and Miocene deposits of the Great Plains. Am. Philos. Soc., Proc., vol. 41, 1902, pp. 113–131.

Gering, Arikaree, Ogalalla, Monroe Creek, Harrison, and Nebraska of Scott; classification of the Oligocene and Miocene; "lake-bed" hypothesis of origin disproved in favor of fluviatile, flood-plain, and eolian hypothesis.

HAWORTH, E. Physical properties of the Tertiary [of Kansas]. Univ. Geol. Survey Kansas, vol. 2, 1896, pp. 247-281.

Rejects "lake-basin" hypothesis in favor of hypothesis of fluviatile origin of Tertiary of Kansas.

HAY, R. Northwest Kansas; its topography, geology, climate, and resources. Kansas State Bd. Agr., 6th Bien. Rept., 1889.

See especially discussions of the Tertiary geology of Kansas.

IRVING, J. D. The stratigraphical relations of the Browns Park beds of Utah. New York Acad. Sci., Trans., vol. 15, Sept., 1896, p. 252.

The beds in Browns Park Valley assigned to the Pliocene.

KNOWLTON, F. H. Fossil flora of the John Day basin, Oregon. U. S. Geol. Survey, Bull. No. 204, 1902.

Geology, pp. 14-20, 102-108. Mascall formation referred to upper Miocene.

LEIDY, J., and LUCAS, F. A. Fossil vertebrates from the Alachua clays of Florida. Wagner Free Inst. Sci., Trans., vol. 4, 1896, pp. vii-xiv, 15-61.

Mastodon floridanus, Aphelops fossiger, A. malacorhinus, Procamelus major, P. medius, P. minimus, Hippotherium plicatile, H. gratium, Equus major.

LOOMIS, F. B. Two new river reptiles from the titanothere beds. Am. Jour. Sci., Dec., 1904, 4th ser., vol. 18, pp. 427-432.

Flood-plain origin of *Titanotherium* beds.

LUCAS, F. A. See LEIDY, J., and LUCAS, F. A.

MATTHEW, W. D. Is the White River Tertiary an eolian formation? Am. Naturalist, vol. 33, 1899, pp. 403-408.

Summary of the paleontologic evidence against the lake-basin hypothesis.

——— Fossil mammals of the Tertiary of northeastern Colorado. Am. Mus. Nat. Hist., Mem. 1, pt. 7, Nov., 1901.

Stratigraphy of White River formation (Horsetail Creek, Cedar Creek, and Martin Canyon beds); of Loup Fork formation (Pawnee Creek beds). Evidence as to mode of deposition (chiefly eolian); analysis of faunæ; correlation of horizons; systematic descriptions.

——— The fauna of the *Titanotherium* beds at Pipestone Springs, Mont. Am. Mus. Nat. Hist., Bull., vol. 19, 1903, pp. 197-226.

Notes on stratigraphy; systematic descriptions of new fossil mammals.

——— A lower Miocene fauna from South Dakota. Am. Mus. Nat. Hist., Bull., vol. 23, 1907, 169-219.

Lower and upper Rosebud formations and faunæ; comparison with American Oligocene and Miocene faunæ New Carnivora, Rodentia, Artiodactyla

——— and GIDLEY, J. W. New or little-known mammals from the Miocene of South Dakota. Am. Mus. Nat. Hist., Bull., vol. 20, 1904, pp. 241-271.

Upper Miocene Loup Fork beds, geology and faunal list; lower Miocene Rosebud beds (new name) New Carnivora and Rodentia

MERRIAM, J. C. A contribution to the geology of the John Day basin. Univ. California, Bull. Dept. Geology, vol. 2, 1901, p. 269.

Geology, faunæ, and floræ of the Cretaceous (Chico and Knoxville), Eocene (Clarno), Oligocene (John Day series) Columbia lava, Miocene (Mascall) Pliocene (Rattlesnake), Quaternary.

——— Carnivora from the Tertiary formations of the John Day region. Univ. California, Bull. Dept. Geology, vol. 5, 1906, pp. 1-64, pls. 1-6.

Brief notes on the Tertiary formations of the John Day region Description of the Canidæ and Felidæ John Day carnivores more advanced in structure than White River carnivores, less advanced than Loup Fork carnivores.

[OSBORN, H. F.] Professor Fraas on the aqueous vs. eolian deposition of the White River Oligocene of South Dakota. Science, n. s., vol. 14, 1901, pp. 210–212.

Titanotherium beds formed by river and flood-plain deposits exposed during dry season. Middle *Oreodon* beds deposited by a shallow lake with dissolved materials of varying concentration (cf. banded layers). Upper *Oreodon* beds formed by eolian loess.

OSBORN, H. F. See SCOTT, W. B., and OSBORN, H. F.

——— and WORTMAN, J. L. Perissodactyls of the lower Miocene White River beds. Am. Mus. Nat. Hist., Bull., vol. 7, 1893, pp. 343–375.

Oligocene.

——— ——— Fossil mammals of the lower Miocene White River beds; collection of 1892. Am. Mus. Nat. Hist., Bull., vol. 6, 1894, pp. 199–228.

Succession of species in the White River "Miocene" [=Oligocene].

PETERSON, O. A. Osteology of *Oxydactylus*. A new genus of camels from the Loup Fork of Nebraska, with descriptions of two new species. Carnegie Mus., Ann., vol. 2, No. 3, Feb., 1904.

Geologic notes and section, pp 473–475.

——— Description of new rodents and discussion of the origin of *Dæmonelix*. Carnegie Mus., Mem., vol. 2, 1905, pp. 139–191.

New rodents from the *Dæmonelix* beds, Harrison formation (Miocene). *Dæmonelix* explained as the cast of a spiral burrow made by rodents (*Steneofiber*).

——— The Agate Spring fossil quarry. Carnegie Mus., Ann., vol. 3, No. 4, 1906, pp. 487–494.

Horizon regarded as equivalent to the top of the lower Harrison formation.

——— The Miocene beds of western Nebraska and eastern Wyoming and their vertebrate faunæ.

Carnegie Mus., Ann., vol. 4, No. 1, 1906, pp. 21–72.

——— New suilline remains from the Miocene of Nebraska. Carnegie Mus., Ann., vol. 2, No. 8, 1906, pp. 305–320.

N. sp. in *Thinohyus*. Comparison with John Day species shows greater specialization, p. 320.

SCOTT, W. B. The mammals of the Deep River beds. Am. Naturalist, vol. 27, 1893, pp. 659–662.

Preliminary description

——— The later Tertiary lacustrine formations of the West. Geol. Soc. America, Bull., vol. 5, 1893 (1894), pp. 594–595.

Nebraska formation, *Cosoryx* beds. Type reference.

——— The Mammalia of the Deep River beds. Am. Philos. Soc., Trans., n. s., vol. 18, 1895, No. 2, pp. 55–185.

Geology, pp. 55–63. European homotaxis with Sanson and Simorre (middle Miocene).

——— and OSBORN, H. F. Preliminary account of the fossil mammals from the White River formation contained in the Museum of Comparative Zoology. Mus. Comp. Zool. Harvard Coll., Bull., vol. 13, 1887, pp. 152–171.

SCUDDER, S. H. The Tertiary insects of North America. U. S. Geol. Survey Terr., Rept., vol. 13, 1890.

Map of the Tertiary lake basin at Florissant, Colo. Geology of the deposits yielding Tertiary insects in America. Florissant=Amyzon beds (Oligocene?). Volcanic origin of the deposits.

SINCLAIR, W. J. New or imperfectly known rodents and ungulates from the John Day series. Univ. California, Bull. Dept. Geology, vol. 4, 1905, pp. 125–143.

STERNBERG, C. H. The Loup Fork Miocene of western Kansas. Kansas Acad. Sci., Trans., vol. 20, pt. 1, 1904, pp. 71–74.

Mode of deposition discussed.

WORTMAN, J. L. On the divisions of the White River or lower Miocene of Dakota. Am. Mus. Nat. Hist., Bull., vol. 5, 1893, pp. 95–106.

Description and stratigraphic table of the *Titanotherium* and *Oreodon* beds; *Protoceras* beds; faunal distribution and succession of types.

——— See OSBORN, H. F., and WORTMAN, J. L.

PLEISTOCENE.

BEEDE, J. W. See HAWORTH, E., and BEEDE, J. W.

COPE, E. D. Description of some vertebrate remains from the Port Kennedy bone deposit. Acad. Nat. Sci. Philadelphia, Proc., vol. 11, 1876, pt. 2, pp. 193–267.

Pleistocene.

——— The Silver Lake of Oregon and its region. Am. Naturalist, vol. 23, 1889, pp. 970–982.

Pleistocene. Fauna and geology.

——— and WORTMAN, J. L. An account of the mammalian fauna of the post-Pliocene deposits of Indiana. State Geol. Indiana, 14th Rept., pt. 2, 1884.

Pleistocene.

FURLONG, E. L. An account of the preliminary excavations in a recently explored Quaternary cave in Shasta County, Cal. Science, n. s., vol. 20, July 8, 1904, pp. 53–54.

Faunal lists.

——— The exploration of Samwel Cave. Am. Jour. Sci., September, 1906, 4th ser., vol. 22, pp. 235–247.

Pleistocene.

——— Reconnoissance of a recently discovered Quaternary cave deposit near Auburn, Cal. Science, n. s., vol. 25, 1907, pp. 392–394.

Faunal lists.

GILBERT, G. K. See HALL, J., and GILBERT, G. K.

HALL, J., and GILBERT, G. K. Notes and observations on the Cohoes mastodon. Notes of investigations at Cohoes with reference to the circumstances of the deposition of the skeleton of *Mastodon*. New York State Cab. Nat. Hist, 21st Ann. Rept., 1871.

Characteristic sections of Pleistocene deposits.

HATCHER, J. B. Discovery of a musk-ox skull (*Ovibos cavifrons* Leidy) in West Virginia, near Steubenville, Ohio [by Sam Huston]. Science, vol. 16, 1902, p. 707.

Faunal changes in the region during glacial period.

HAWORTH, E., and BEEDE, J. W. The McPherson *Equus* beds [of Kansas]. Univ. Geol. Survey Kansas, vol. 2, 1896 (1897), pp. 287–296.

MATTHEW, W. D. List of the Pleistocene fauna from Hay Springs, Nebr. Am. Mus. Nat. Hist., Bull., vol. 16, 1902, pp. 317–322.

Hay Springs (Nebraska), Silver Lake (Oregon), Oregon Desert, Washtuckna Lake (Washington).

Mercer, H. C. The bone cave at Port Kennedy, Pa. Acad. Nat. Sci. Philadelphia, Jour., vol. 11, 1899, pt. 2.

Referred to the Pleistocene, but without comparison with other cave formations and faunæ.

Merriam, J. C. Recent cave exploration in California. Am. Anthropologist, n. s., vol. 8, 1906, pp. 221–228.

Mercer's, Potter Creek, Samwel, and Stone Man caves, probably of Quaternary age.

Scudder, S. H. The effect of glaciation and of the glacial period on the present fauna of North America. Am. Jour. Sci., Sept., 1904, 3d ser., vol. 48, pp. 179–187.

Shufeldt, R. W. A study of the fossil avifauna of the *Equus* beds of the Oregon desert. Acad. Nat. Sci. Philadelphia, Jour., vol. 9, 1892, p. 389.

Sinclair, W. J. A preliminary account of the exploration of the Potter Creek cave, Shasta County, Cal. Science, n. s., vol. 17, 1903, pp. 708–712.

——— The exploration of the Potter Creek cave. Univ. California, American Archæology and Ethnology, vol. 2, 1904, pp. 1–27, pls. 1–14.

Late Quaternary age.

——— New Mammalia from the Quaternary caves of California. Univ. California, Bull. Dept. Geology, vol. 4, 1905, pp. 145–161.

Williston, S. W. An arrowhead found with bones of *Bison occidentalis* in western Kansas. Am. Geologist, vol. 30, 1902, pp. 313–315.

Arrowhead in undoubted association with an extinct species, *Bison occidentalis*, in beds referred by Williston to the *Equus* beds.

——— The Pleistocene [of Kansas]. Univ. Geol. Survey Kansas, vol. 2, 1896, pp. 299–308.

Kansas Pleistocene deposits and faunæ.

Wortman, J. L. See Cope, E. D., and Wortman, J. L.

CHAPTER I.

GENERAL GEOLOGIC AND CLIMATIC HISTORY OF THE TERTIARY.

Although, as observed in the introduction (p. 7), we still lack exact knowledge, certain broad generalizations are beginning to emerge from the facts collected chiefly by American paleontologists since the pioneer studies of Hayden and Leidy in the middle of the last century.

Among the earlier contributors to our geologic and stratigraphic knowledge are Hayden, Leidy, Marsh, Cope, King, Scott, and Osborn. Among the more recent contributors are Matthew, Hatcher, Wortman, Darton, Merriam, Peterson, Douglass, Gidley, Granger, and Sinclair.[a]

The most central fact established is that there were during the Tertiary period two grand natural divisions of geologic deposition and of animal and plant habitat, similar to the two natural divisions which exist to-day, namely, (1) the Mountain Region and (2) the Plains Region.

THE MOUNTAIN REGION.

The mountain and high-plateau region, as a whole, stretched north through British Columbia to its broad Asiatic land connection, which was apparently interrupted and renewed more than once during the Tertiary period. On the south it terminated, according to Suess, in the mountains which form the northern boundary of the southern Mexican State of Oaxaca. We have a few glimpses of the life of limited areas of this vast region in Tertiary time.

The Eocene Tertiaries of the Mountain Region, lying in and west of the Rockies, in which the life is best known, were partly formed by the post-Cretaceous or post-Laramie uplift, accompanied by great volcanic activity, lava flows, and eruptions of volcanic dust, and by the formation of a series of lake, river, and flood-plain basins, filled with volcanic and erosion sediments.

---

[a] Six of these observers either have been continuously or were for a time connected with the expeditions sent out by the present writer from the department of vertebrate paleontology of the American Museum of Natural History, with instructions to combine very precise geologic and paleontologic observations. Of the others, Hatcher's pioneer work for the United States Geological Survey and for the Carnegie Museum, Merriam's and Sinclair's work in the John Day region (University of California studies), and Douglass's observations in Montana have been most important. Darton's report on the central Great Plains (1905) is the latest and most comprehensive contribution.

The mammalian life of this region from New Mexico on the south to Montana on the north is fully known from the beginning to the close of the Eocene epoch, while it is imperfectly known during the Miocene and Pliocene epochs. It shows four phases in its relations to Europe.

1. Throughout the lower Eocene epoch it is closely similar to the far-distant life of western Europe. (See first and second faunal phases, pp. 33, 35–36.)

2. There follows a middle and upper Eocene interval of faunal separation from Europe. (See third faunal phase, pp. 42–43.)

3. Again there is a faunal reunion, near the beginning of the Oligocene epoch; then a divergence, less marked than before; then a reunion in the middle Miocene, and another in the Pleistocene. But from the Oligocene onward western America, northern Asia, and Europe, or Eurasia, form a single great zoologic province until the late Pleistocene. (See fourth, fifth, and sixth faunal phases, pp. 57–60, 76, 82.)

4. Finally, the present epoch is one of faunal divergence or separation. (See seventh faunal phase, p. 84.)

THE PLAINS REGION.

The Tertiaries of the Plains Region lie east of the Rockies from Montana southward.

During the entire Eocene epoch the country stretching to the Mississippi and eastward to the Appalachians and Atlantic coast is, with a few exceptions,[a] a terra incognita so far as its terrestrial mammalian life is concerned. Glimpses only of its marine or seashore mammalian life are afforded in the *Zeuglodon* zone[b] of Alabama and Florida and in other littoral marine deposits. While this vast eastern region contains no known Eocene mammal-bearing deposits, it was undoubtedly the scene of a very active continental[c] mammalian life from the time of the emergence of the central area toward the close of the Cretaceous, or during and after Laramie time. Yet our knowledge of the life of eastern North America during the entire Eocene is only what we gain by inference from our knowledge of the life of the Mountain Region from Montana on the north (47°) to New Mexico on the south (36° latitude), a relatively circumscribed area.

Our earliest knowledge of the mammalian life of the Great Plains is that suddenly afforded on its extreme western fringe or border in lower Oligocene time, and it is indeed a revelation. Again, with the

[a] For example, Marsh has reported from the supposed Oligocene of New Jersey two species of mammals, *Elotherium* and *Protapirus* (*Tapiravus*) *validus*.

[b] *Zeuglodon* is an aberrant whale-like form which probably originated in the Eocene of North Africa.

[c] As pointed out by Suess, North America has been a continent since the close of the Cretaceous, and its great land surfaces are older, more permanent, and more extensive than those of Europe. The land surfaces of Africa, however, are far older than either.

exception of important upper Miocene ("Peace Creek" and "Archer" formations) and possibly mid-Pliocene deposits in Florida, the country east of the Great Plains remains unknown until the lower Pleistocene.

These facts, which are often overlooked by paleontologists, have a very important bearing on theories as to the source or origin of the new forms of mammals which suddenly appear from time to time.

RESEMBLANCES AND CONTRASTS BETWEEN MOUNTAIN AND PLAINS REGIONS.

Resemblances.—Opening with a moderately warm and humid but far from tropical climate, with mild winters, the common physiographic and climatic history of both the Mountain and western Plains regions was that of progressive elevation, slowly progressing aridity, gradual soil denudation and deforestation, progressively sharper definition of the winter and summer seasons, concluding with destruction of most of the larger forms of life during the lower Pleistocene glacial epoch.

Contrasts.—The geologic history of the two regions presents some strong contrasts.

First, with some exceptions, the Tertiary deposits of the Mountain Region are in clearly defined basins drained by the same great river systems which drain them to-day, while those of the Plains Region are widely scattered over broad areas, with frequent changes in the river courses, the present river courses being comparatively modern.

Second, it follows that in the Mountain Region, from the basal Eocene to the summit of the upper Oligocene or John Day formation, there was little or no working over of the older Tertiary rocks into newer deposits, but there exist a number of continuous local depositions. Erosion of these depositions has been retarded fortunately in the John Day basin of Oregon by heavy cappings of lava, in the Bridger basin by a dense Pleistocene (?) conglomerate, and in the Washakie basin by a fine conglomerate. Broad expanses of these historic strata have thus been preserved in their original purity and continuity for the geologist and paleontologist.

Third, by contrast, in the Plains Region the original very extensive Oligocene strata were in part worked over to form Miocene strata, and these in turn were in part eroded to form Pliocene strata; again, all three contributed to the Pleistocene strata; and finally all four are now contributing to the alluvium of the Great Plains. Thus in the Plains Region we find Miocene river deposits laid in old Oligocene channels, and Pliocene deposits embedded in Miocene channels, as well illustrated in Gidley's sections[a] in the Llano Estacado of Texas

[a] Gidley, J. W., The fresh-water Tertiary of northwestern Texas. American Museum expeditions of 1899–1901: Bull. Am. Mus. Nat. Hist., vol. 19, 1903, pp. 617–635.

(fig. 15, p. 82). This succession of depositions and erosions has rendered the Tertiary geologic history of the Great Plains very complicated, and has retarded our geologic and paleontologic solutions.

Fourth, owing to the proximity of the volcanic zones, volcanic ash and other fine eruptive materials contributed very largely and in some basins almost exclusively to the Eocene and Oligocene deposits in the Mountain Region, while in the Plains Region, which was more distant from the active craters, volcanic-ash deposits were occasional, and conglomerates, sandstones, and clays make up the main mass of the deposits. In some Plains deposits, however, volcanic ash is a large component.

Fifth, the mammalian life of the Mountain Region was largely that of plateaus, uplands, and elevated basins, of streams and lake borders, of hillsides, and more or less of the forests. The mammalian life of the Plains Region was that of savannas and pampas, of broader plains and rivers, with more restricted forests. There was, however, no sharp life demarcation, because then, as now, some of the Plains types penetrated the Mountains and some of the Mountain types penetrated the Plains.

General homotaxis of some of the Mountain and Plains formations.

	MOUNTAIN BASIN DEPOSITS.	GREAT PLAINS DEPOSITS.	
	Geologic.—Partly of erosion materials; largely of volcanic materials, partly eolian, partly deposited in water. *Faunistic.*—Extinct mammals, chiefly inhabiting a mountainous, hilly, forested, lake- and river-border, well-watered country.	*Geologic.*—Largely of water-erosion and wind-erosion materials; partly of volcanic materials. *Faunistic.*—Extinct mammals, chiefly of an open-plains country, traversed by broad, slow-moving rivers, savanna, partly forested, with shallow lakes and decreasing rain supply.	
Middle Pliocene		Blanco, Tex.	Second deposition period of very widespread fluviatile, flood-plain, and eolian deposits, chiefly erosion and volcanic materials, on the Great Plains of Dakota, Nebraska Colorado, and western Kansas. Limited and scattered deposits in the Rocky Mountain region.
Lower Pliocene or upper Miocene.		Ogalalla, in part ("Republican River"), Nebr.	
Upper Miocene	Rattlesnake, Oreg.	Ogalalla ("Nebraska"), Nebr.	
Middle Miocene	Deep River, Mont.; Mascall, Oreg.	"Pawnee Creek," Colo.	
Lower Miocene and upper Oligocene.	"Fort Logan," Mont.; John Day (upper part), Oreg.	Arikaree (Gering Rosebud), Nebr.	
Upper Oligocene	John Day (middle and lower parts), Oreg.	White River, S. Dak. (upper part).	
Lower Oligocene	Deposits on Pipestone Creek, Mont.	White River (lower part), of the western plains, of South Dakota, Nebraska, etc.	
Upper Eocene	Uinta, northern Utah		First deposition (or Eocene) period of lacustrine, river, and flood-plain deposits, largely of volcanic materials in the Rocky Mountain basin, chiefly in the ancient drainage basin of Colorado River. Plains deposits of this period eroded away, buried, or unknown.
Middle Eocene	"Washakie," Wyo.; Bridger, Wyo.; Wind River, Wyo.		
Lower Eocene	Wasatch, N. Mex. and Wyo.		
Basal Eocene	Torrejon, N. Mex.; Puerco, N. Mex.; Fort Union, Mont.		

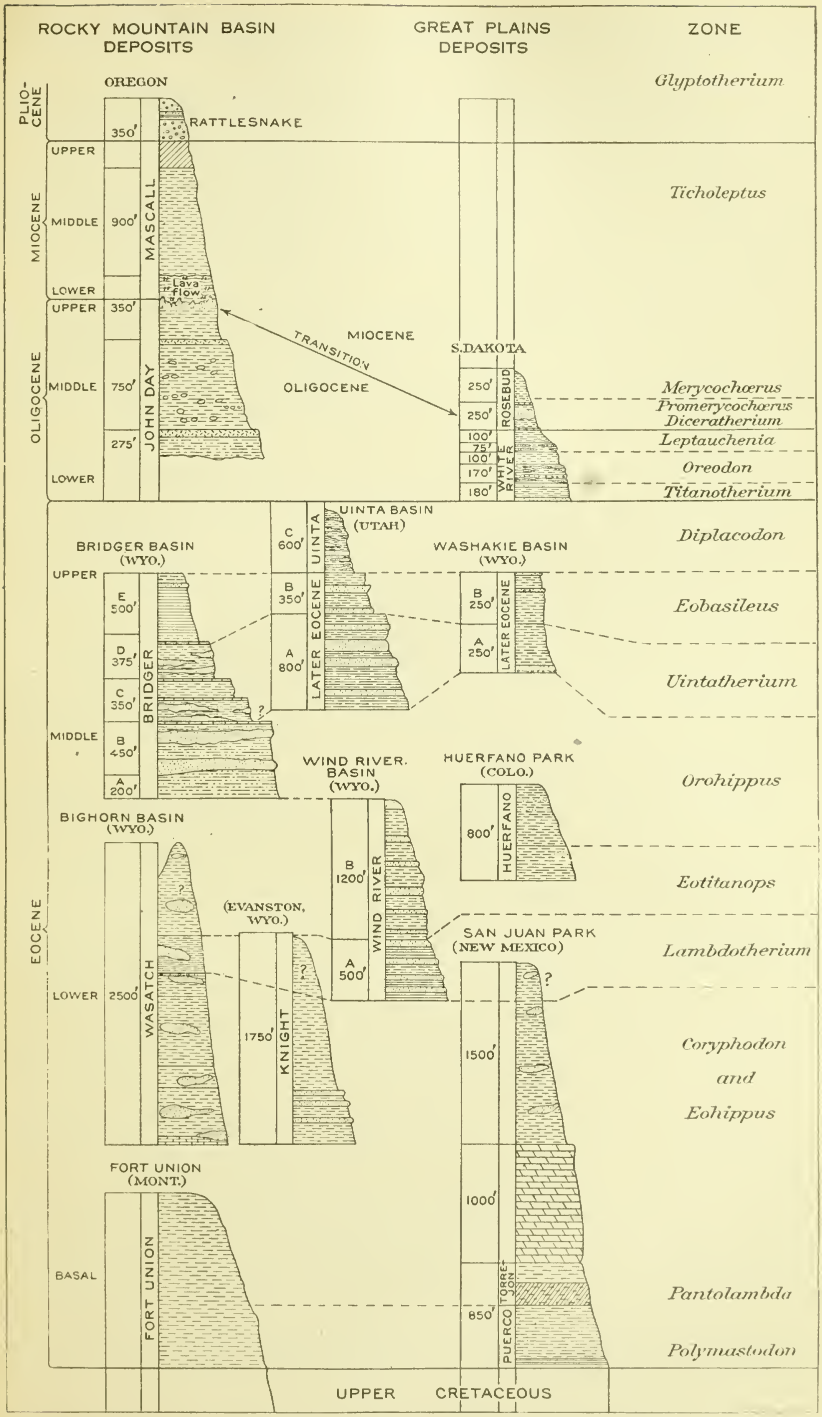


Fig. 1. Composite section of the Tertiary deposits of the West. The thickness of these deposits is represented on the same scale throughout. The correlations indicated by dotted lines are preliminary.

GEOLOGIC HISTORY OF MOUNTAIN BASIN DEPOSITS OF THE EOCENE AND OLIGOCENE.

The combination by faunistic correlation of all the Eocene sections, as represented in fig. 1, gives a total thickness of 7,200 feet.

The deposits are distinguished by the following chief characters:

1. The axes of the mountain ranges were the same as at present. The mountain ranges, in relation to the surrounding country, were probably higher than at present, because we must allow for two to three million years of erosion.

2. The Eocene drainage systems were broadly the same as the modern, namely, the systems of Colorado River, Arkansas River, the Bighorn branch of Missouri River, and Columbia River. In details, however, the drainage systems have certainly been modified by uplift and erosion.

3. The deposits all lie in the same great mountain basins or mountain valleys in which they were originally deposited. (See Pl. I.)

4. Except close to the mountain foothills (e. g., Wasatch of the Bighorn Basin) there has been comparatively little Eocene or post-Eocene disturbance, because these deposits are still horizontal or at gentle angles with their original horizontal position.

5. The surrounding mountain ranges were interspersed with active volcanic peaks; the upper Colorado River basin especially was surrounded by a circle of volcanoes which poured out their lava and widely distributed their ashes.

6. From preliminary lithologic examinations the Eocene deposits have been found to consist largely, sometimes exclusively, of volcanic-ash materials.[a] The subject has an interesting history: In 1885–86 Merrill and Peale determined the volcanic-ash origin of the "Bozeman lake beds" in Gallatin County, Mont. Peale's conclusions were interesting.[b] These observations are in line with King's[c] (1876) previous recognition of volcanic-ash strata in the typical Wasatch of Evanston, Wyo., immediately underlying the true *Coryphodon* zone of Marsh, with Wortman's note as to the volcanic-ash nature of the Huerfano basin Pliocene, and with a number of obser-

---

[a] It is interesting to note the similar volcanic-ash character of the Santa Cruz, the chief Miocene formation of Patagonia.

[b] Peale, A. C., Science, vol. 8, Aug. 20, 1886, p. 163. The article concludes as follows:

"Will we not, therefore, have to cut down very materially the great length of time generally believed to have elapsed in this region from the beginning of this lacustrine period to the present time, when we find that a great portion of the sediment that once filled the lakes is due, not to the products of erosion, as has hitherto been supposed, but to repeated showers of volcanic dust? Again, do not these volcanic materials, which must have fallen in showers over a large extent of country—accumulating in some cases in beds 40 to 90 feet thick—account for the perfect preservation of the vertebrate remains which characterize the formations in so many parts of the West; and is there not also suggested one possible cause for the extinction of some of the many groups of animals which have at present no descendants in this region, and whose only remains are the bony fragments found in these lacustrine deposits?"

[c] Am. Jour. Sci., 3d ser., vol. 11, 1876, pp. 478–480.

vations (Barbour, Darton, and others) as to the volcanic-dust composition of certain Oligocene to Pliocene sands in Nebraska, Montana, and Colorado. Following Merriam's[a] determination (1901) of the volcanic-ash nature of the deposits of the John Day basin, the next important step of recent years in relation to the Eocene lake basins is the recognition by Sinclair[b] (1906) that the deposits of the Bridger basin, previously described as sandstones and clays, are also chiefly of volcanic nature or tuffs. The neighboring Washakie basin deposits are of ash (Sinclair, 1907). On preliminary examination the same observer finds tuffs in the Torrejon, Wasatch, Wind River, and Uinta, as well as in the Bridger; in other words, in the entire Eocene series. The lower part of the Wind River formation, however, and probably parts of other basin deposits, appear to be true sandstones and clays. Veatch[c] (1906) confirms King's observation that just below the typical *Coryphodon* zone of Evanston are extensive "white beds" largely composed of volcanic ash, which he names the Fowkes formation.

7. The manner of deposition of volcanic ash in these various basins, whether blown about on a dry surface, in flood plains, or in either extensive or shallow lakes, has not been fully determined. In the Bridger formation the ash shows little evidence of prolonged water erosion. Merriam rejects the lacustrine theory of the origin of the John Day formation and speaks of "showers of ash, with tuff deposits on a plain occupied in part by shallow lakes."

8. Admirable studies of the John Day Oligocene, in most of its biotic and geologic aspects, have been made by Merriam,[a] Sinclair,[d] and Knowlton.[e] (See p. 67.)

9. The Bridger formation, 1,800 feet in thickness, is the only Eocene deposit which has been exactly examined[f] from the standpoint of geology, petrography, and paleontology. Wind-blown volcanic ash, glass, and eruptive feldspar are large ingredients of this formation, which contains no erosion materials from the adjacent Uinta Mountains, such as we should expect to find. There is evidence of the direct deposition of the ash in water, with some working over of the

---

[a] Merriam, J. C., A contribution to the geology of the John Day basin: Bull. Dept. Geology, Univ. California, vol. 2, No. 9, April, 1901, pp. 269-314.

[b] Sinclair, W. J., Volcanic ash in the Bridger beds of Wyoming: Bull. Am. Mus. Nat. Hist., vol. 22, 1906, pp. 273-280.

[c] Veatch, A. C., Geography and geology of a portion of southwestern Wyoming, with special reference to coal and oil: Prof Paper U S. Geol. Survey No. 56, 1907.

[d] Sinclair, W. J., New or imperfectly known rodents and ungulates from the John Day series: Bull. Univ. California, Dept. Geology, vol 4, 1905, pp. 125-143.

[e] Knowlton, F. H., Fossil flora of the John Day basin, Oregon: Bull. U. S. Geol. Survey No. 204, 1902, 153 pp.

[f] The writer planned this survey in preparation for the United States Geological Survey monograph on the titanotheres, desiring to ascertain whether or not the Eocene titanotheres were horizontally distributed, i. e., in vertically successive life zones. As conducted by and reported on by Messrs Matthew, Granger and Sinclair, partly for the United States Geological Survey, but chiefly for the American Museum expeditions, it succeeded far beyond our most sanguine anticipations.

coarser materials by streams into the so-called sandstones, while the finer materials, constituting the so-called clays, are actually tuffs. Proofs of temporary lacustrine conditions, or of prolonged high water on base-level, are found in the very widely extended so-called white layers containing calcite and flint; these divide the Bridger formation into five levels (A, B, C, D, E), each characterized by distinctive specific forms of mammalian and reptilian life. These levels demonstrate periodic risings of the water level in this basin.

10. As the fossil mammals which all these Eocene mountain deposits contain are carefully compared and studied, we nearly, if not quite, demonstrate another great fact, namely, that these deposits were successively formed, in one basin after another, throughout the Eocene period; in a number of cases, fortunately, there was a time overlap—in other words, before one deposition closed another began. When fully explored they will thus afford a nearly continuous history of the vertebrate life of the Mountain Region during the Eocene and Oligocene epochs.

GEOLOGIC HISTORY OF THE GREAT PLAINS DEPOSITS OF THE OLIGOCENE TO LOWER PLEISTOCENE.

Extent.—The Oligocene to Pleistocene deposits immediately overlie the various divisions of the Cretaceous and form the surface of the plains at different points from 200 to 300 miles east of the Rocky Mountains, from British Columbia on the north to the Mexican plateau on the south, with a combined maximum thickness of about 2,000 feet. Their central area is best shown in Darton's preliminary geologic map of the central Great Plains.[a]

History of opinion as to mode of deposition.[b]—The lacustrine-origin theory as to the Great Plains deposits was entertained by Owen, King, Hayden, Leidy, Cope, Marsh, Scott, and Darton; it reached its climax in King's proposal to give names to each of the great successive lakes, beginning with those in the Mountain Region. This theory of lake basins of very large extent on the Great Plains has been abandoned in the light of more exact paleontologic and geologic study.

Among the geologists, Johnson,[c] Gilbert,[d] Haworth, and especially Davis, who reviewed the whole subject in a broad and critical way, have advocated a fluviatile and flood-plain origin. Hatcher, Fraas, and recently Darton have also set forth strong reasons for fluviatile

---

[a] Preliminary report on the geology and underground-water resources of the central Great Plains: Prof. Paper U. S. Geol. Survey No. 32, 1905, pl. 35.

[b] The history of opinion is fully traced in Davis, W. M., The fresh-water Tertiary formations of the Rocky Mountain region: Proc. Am. Acad. Arts and Sci., vol. 35, No. 17, March, 1900, pp. 346–373.

[c] Johnson, W. D., The High Plains and their utilization: Twenty-first Ann. Rept. U. S. Geol. Survey pt. 4, 1901, pp. 601–741; Twenty-second Ann. Rept., pt. 4, 1902, pp. 631–669.

[d] Gilbert, G. K., The underground waters of the Arkansas Valley in eastern Colorado: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 2, pp. 553–601.

or river-channel and flood-plain origin; for river-channel, backwater, lagoon, and shallow-lake origin (Fraas); for flood-plain and eolian origin (Hatcher, 1902 [a]) of various portions of these scattered deposits (Darton).

Among paleontologists, Matthew (1899,[b] 1901[c]) especially attacked the lacustrine theory of the origin of the White River clay of Colorado on both paleontologic and geologic grounds, and set forth cogent reasons for a diametrically opposed eolian theory, comprising a river and flood-plain origin for the sandstones, and a partly backwater and lagoon but chiefly eolian sedimentation for the clays. His paleontologic analysis shows that the fine Oligocene clays contain chiefly the terrestrial and plains animals and thus represent overflow and still-water formations, while the sandstones traversing these clays are contemporaneous, but contain chiefly the forest and fluviatile animals, and thus represent rapid-water (river) formations.

The paleontologic evidence taken alone strongly favors the theory of dry-land sedimentation of the so-called Oligocene clays, because the entire fauna is terrestrial, while aquatic types are wholly wanting. Thus Matthew [d] concludes in favor of an eolian theory:

> But the nature of the organic remains, where such have been found, seems to definitely negative the idea of any vast lake, and to favor less the theory of a series of lagoons and swamps than that of a broad, open, and comparatively dry plain, with shallow, probably wooded rivers meandering over parts of it, and deposits partly or chiefly brought by rivers, but in large part redistributed over the higher sodded grass land by the agency of the wind. This would mean an approximation to the present conditions of climate, though probably not so dry as that of the region now is.

Osborn,[e] after a personal survey of the South Dakota Oligocene and lower Miocene section (see Pl. III) in 1906, in general supports the view of Matthew and Hatcher that the lacustrine theory is entirely untenable, but he holds that the eolian theory for the White River Oligocene deposits is also untenable. The chief geologic evidence against the eolian theory as applied to certain areas of the Oligocene or Brule clay (*Oreodon* and *Leptauchenia* zones) is the absolutely regular horizontal banding, miles in extent, which points to deposition in tranquil sheets of water. In fact, this banding of the light-colored finer portions of the Brule clay, and even of portions of the underlying Chadron formation, militates as strongly against the eolian theory as the paleontologic evidence militates in favor of it. These buff, horizontally banded strata are, on certain levels, abruptly traversed by grayish to greenish

---

[a] Hatcher, J. B., Origin of the Oligocene and Miocene deposits of the Great Plains: Proc. Am. Philos. Soc., vol. 41, 1902, pp. 113–132.

[b] Matthew, W. D., Is the White River Tertiary an eolian formation? Am. Naturalist, vol. 33, 1899, pp. 403–408.

[c] Matthew, W. D., Fossil mammals of the Tertiary of northeastern Colorado: Mem. Am. Mus. Nat. Hist., vol. 2, pt. 7, 1901, pp. 359–368 (conditions of deposition).

[d] Op. cit., 1901, p. 364.

[e] Tertiary mammal horizons of North America: Bull. Am. Mus. Nat. Hist., vol. 23, 1907, p. 237.

river-channel beds of coarse materials, from 700 feet to a mile in width, with an easterly direction. The most tenable theory at present seems to be that of periodic overflow deposition in very shallow sheets of water, too transitory or seasonal to support any of the aquatic animals—such deposition as is left by the annual overflow of the Nile, for example. The nilometer at Roda shows an annual accumulation of silt of 0.12 centimeter, equivalent to 12 meters in ten thousand years, as cited by Lyons [a] and by Beadnell.[b]

Summary.—The sum of the present opinion appears to be this: The topography of the Plains Region was in Oligocene to lower Pleistocene time, as now, level or gently undulating, not mountainous. On the gentle eastward slopes of the Rocky Mountains and the Black Hills were borne broad streams with varying channels, backwaters, and lagoons, sometimes spreading into shallow lakes but never into vast fresh-water sheets. Savannas were interspersed with grass-covered pampas, traversed by broad, meandering rivers which frequently changed their channels.

This accounts for the presence of true conglomerates, true sandstones, calcareous grits, gypsum, fine clays, fuller's earth, fine loess, eolian sands, and even, far out on the plains of Nebraska [c] and Kansas, widespread deposits of volcanic dust, wind borne from distant craters in the mountains to the west and southwest. In the early Oligocene and Miocene the deposits were chiefly fluviatile or river sandstones and conglomerates interspersed with fine flood-plain or overflow deposits, perhaps locally lacustrine, partly of volcanic ashes. This interpretation is presented in Pl. III, which has been prepared to show the actual relations of the unstratified stream-channel deposits to the finer and partly stratified surrounding deposits. These rocks still await petrographic analysis.

As the desiccation or aridity of the country increased, the mountain-fed rivers became smaller and narrower, while the eolian or loess deposits apparently became more common, beginning in the middle Miocene. The deposits also became more and more restricted in extent as the Miocene advanced. The newer river channels cut down into the older series, thus using the erosion materials a second time.

Thus geology and petrography unaided fail to complete the picture. Paleontology goes hand in hand with these sciences to restore the true picture of former conditions on the Great Plains; but far more extensive petrographic and paleontologic investigation than has as yet been made is necessary to establish a final geologic theory.

---

[a] Lyons, H. G., The physiography of the River Nile and its basin: Survey Dept. Egypt, Cairo, 1906, pp. 313, 317, 334.

[b] Beadnell, H. J. L., The topography and geology of the Fayûm province of Egypt: Survey Dept. Egypt, Cairo, 1905, p. 80.

[c] See Barbour, E. H., The deposits of volcanic ash in Nebraska: Proc. Nebraska Acad. Sci., 1894-95. The heaviest beds and the coarsest ash occur in the southwestern counties. Even as far east as Missouri River (Cuming County) there are beds 7 feet in thickness.

CHAPTER II.

TIME CORRELATION OF MAMMAL-BEARING HORIZONS.

THE TWO GRAND PROBLEMS.

American correlation.—The first problem is the chronologic correlation of the purely fresh-water American horizons with one another, a problem which in exact form has hitherto made slow progress owing to the very loose methods of collecting fossils for purely anatomic and descriptive purposes without closely recording geologic levels and other geologic data. Now, thanks to the revival of the more exact methods which characterized some of Hayden's and Leidy's work on the Great Plains, there is promise of very rapid progress. Among paleontologists we are indebted to Scott, Wortman, Matthew, Gidley, Merriam, Sinclair, and others, but especially to Matthew's very accurate and complete manuscript faunal lists.[a] Accurate faunal leveling began with Hatcher's explorations of the Chadron formation (*Titanotherium* zone), and has been the invariable rule of the American Museum expeditions since 1901.

American and Eurasiatic correlation.—The second problem, following especially Cope (1879–1884), Marsh (1891), Filhol (1885), Scott (1888–1894), and Osborn (1900), is the approximate chronologic correlation of American horizons with Eurasiatic vertebrate horizons and thus indirectly with European marine invertebrate horizons, which is rendered possible by the well-known alternation of marine and fresh-water horizons over large parts of central Europe. This indirect method of correlation with the European marine stages is facilitated by the partial alternation of marine and fresh-water formations in Florida, as studied by Dall,[b] and will in time establish the western American Tertiaries in the geologic world time scale.

When these two grand problems of American correlation and of American-Asiatic-European-African correlation are worked out we shall be able (1) to establish a complete and very accurate geologic

[a] The most thorough previous correlation of the American Tertiaries is that of Matthew, A provisional classification of the fresh-water Tertiary of the West: Bull. Am. Mus. Nat. Hist., vol. 12, 1899, pp. 19-75. At this writing a second edition is in preparation, the partly completed manuscript of which has been placed at my service by Doctor Matthew. It will be printed herewith as an appendix.—H. F. O. (See pp. 91-120.)

[b] Dall, W. H., Geological results of the study of the Tertiary fauna of Florida, 1886-1903: Trans. Wagner Free Inst. Sci., Philadelphia, vol. 3, pt. 6, 1903, pp. 1541–1620. Also, A table of the North American Tertiary horizons, correlated with one another and with those of western Europe, with annotations: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, pp. 323–348.

time scale for the entire Tertiary and (2) to speak with precision regarding the time of successive migrations, and it is possible that we shall be able (3) to describe our subdivisions in the terms of the stages or étages employed by our European confrères. These are results toward which the writer has worked for many years in cooperation with many colleagues in this country and in Europe.[a]

METHODS OF CORRELATION.

Bases.—The faunistic bases which the writer laid down[a] for European and American correlation were:

1. Percentages of common genera and species. To this families should now be added.

2. Similar stages of detailed evolution in related forms, e. g., Eocene Equidæ, Miocene Rhinocerotidæ.

3. Simultaneous introduction of new forms by migration, e. g., Mastodontinæ in middle Miocene.

4. Predominance or abundance of certain forms, e. g., *Promerycochœrus* in all lower Miocene deposits.

5. Convergence and divergence of faunæ in comparison with Europe and Asia, e. g., lower Eocene, Oligocene, middle Miocene, middle Pleistocene.

6. Extinction of certain forms, e. g., *Steneofiber*, in lower Miocene.

Similarly the correlation of the Tertiaries of northwestern America, inter se, should be based on—

1. Presence of similar specific and generic stages.
2. Evidence of similar local evolution.
3. Dominance or scarcity of similar animals in the fauna.
4. Disappearance or apparent extinction of similar forms.
5. First appearance of similar forms.

It should always be kept in mind that the appearance of a new mammal in any of the Plains or Mountain deposits may occur by migration from one of several possible sources, namely:

1. From the unknown Plains or Mountain regions of eastern North America or of northern North America.
2. From Europe or Eurasia as a whole.
3. From South America.
4. From Africa.
5. From Australia via Antarctica.

Sources of error.—This kind of evidence as to the bases of correlation is subject to two great limitations:

First, imperfections in our records, or the possible presence of animals which have existed in contemporaneous, earlier, or later

[a] Correlation between Tertiary mammal horizons of Europe and America: Ann. New York Acad. Sci., vol. 13, 1900, pp. 3–44. Also, Trial sheets of typical and homotaxial Tertiary horizons, issued in 1897, 1898, and 1900.

geologic stages, but which have not been discovered, owing to the accidents of deposition or to occurrence remote from centers of deposition. We are too apt to assume the absence of a mammal from the entire continent because it has not been found in what was formerly a very restricted region. Many forms previously considered absent from the American Eocene have very recently been discovered; for example, the animals related to the armadillos or Dasypodidæ, found in the Bridger.

Second, the different contemporary conditions of environment and habitat in different parts of the Mountain Region and of the Great Plains Region; that is, local differences of habitat, differences of longitude or of east and west distribution, differences of latitude or of north and south distribution, differences of altitude or vertical distribution—in short, such differences as exist to-day—render correlation somewhat uncertain. Thus, the arboreal primates are very common in the Eocene Mountain deposits, but no trace of them is found in the Oligocene Plains deposits.

PRELIMINARY CORRELATION OF THE EOCENE AND OLIGOCENE MOUNTAIN DEPOSITS.

Correlation of the Mountain Region basins of the Eocene is of necessity almost exclusively paleontologic owing to the uniform repetition of similar geologic and petrographic conditions in the successive basins.

These deposits, as above noted, fortunately overlapped each other in time—that is, before one ceased, its more or less distant neighbor began. The writer and others are now collecting exact data for estimating these overlaps. Fig. 1 presents the writer's preliminary correlation of the Eocene and Oligocene deposits, based on personal studies, with the able cooperation of Matthew, Granger, Sinclair, Loomis, and others.

The chief omissions, which will soon be supplied, are (1) the Fort Union section of south-central Montana (Douglass, 1902), with its fauna equivalent to the Torrejon; (2) the typical Wasatch (*Coryphodon* zone) section, Evanston, Wyo. (Veatch, 1907); and (3) the typical Wind River section (Loomis).

PRELIMINARY CORRELATION OF THE OLIGOCENE TO LOWER PLEISTOCENE MOUNTAIN AND PLAINS DEPOSITS.

The geologic and paleontologic correlation of the Great Plains deposits above the lower Miocene is even more difficult owing (1) to the irregular nature of these deposits and (2) to our present lack of exact analysis of the mammalian fauna.

The accompanying preliminary correlation (fig. 10), based on the researches of Hayden, Leidy, Cope, Scott, Wortman, Merriam,

Gidley, Douglass, Peterson, Sinclair, and others, was prepared by Dr. W. D. Matthew (May, 1906), and embodies some alterations by the writer and by Messrs. Peterson and Douglass (September, 1906). It is to be regarded as largely tentative and incomplete.

Figs. 1 and 13 bring out the following two facts of chief importance:

First, that through examination and comparison of the fauna of local horizons we shall probably be enabled to establish a complete continuity of mammalian life for the entire Eocene, Oligocene, and Miocene epochs of North America in a general sense, but this will never apply to the fauna of the whole Tertiary of either the Great Plains or the Mountain Region.

Second, that while the chief faunistic lacunæ at present are in the American Pliocene, these gaps will probably be filled as time goes on, just as the great lower Miocene gaps which existed only a few years ago have been filled.

CHAPTER III.

WESTERN AMERICAN CENOZOIC HORIZONS.

EOCENE.

I. FIRST FAUNAL PHASE.

Archaic Mesozoic mammals with partly South American, partly European affinities.

POST-CRETACEOUS OR BASAL EOCENE (EUROPE, ÉTAGE THANÉTIEN).[a]

1. PUERCO FORMATION; POLYMASTODON ZONE.

(Fig. 1; Pl. I.)

HOMOTAXIS.

North America.—Puerco formation (500 feet), San Juan basin, northwestern New Mexico.

South America.—A contemporary or previous (i. e., Cretaceous) land connection with South America is indicated by the occurrence of similar mammals in the *Notostylops* zone, Upper Cretaceous or basal Eocene of Patagonia. Additional evidence of South American connection is afforded by the subsequent occurrence of animals related to the Edentata-Dasypoda in the American middle Eocene.

Europe.—No European mammal fauna of this earliest stage is known, therefore no conclusions as to homotaxis can be drawn. It corresponds broadly to the Thanétien.

FAUNA.[b]

In New Mexico and Montana are found small archaic mammals[c] evolving from Cretaceous, Jurassic, and Triassic ancestors. Multituberculata, which originated in the Triassic, 3 families. Two orders of archaic ungulates—(1) Amblypoda-Periptychidæ, (2) Condylarthra-Phenacodontidæ. Archaic Carnivora-Creodonta, 3 families: (1) Oxyclænidæ, (2) Mesonychidæ-Triisodontinæ, (3) Arctocyonidæ

[a] Throughout this paper the French stages Thanétien, Sparnacien, etc., are inserted merely to indicate approximate homotaxis with Europe.

[b] Matthew, W. D., A revision of the Puerco fauna: Bull. Am. Mus. Nat. Hist., vol. 9, 1897, pp. 259–323. (See Appendix to this volume, p. 91.)

[c] In the following pages "Archaic mammals" include members of the orders Multituberculata, Marsupialia, Insectivora, Tæniodonta-Edentata, Amblypoda, and Condylarthra, of Mesozoic origin (hence *Meseutheria* Osborn) and typically of Mesozoic and early Eocene radiation. "Modernized mammals" include members of the orders Primates, Carnivora, Fissipedia, Rodentia, Hyracoidea, Proboscidea, Perissodactyla, and Artiodactyla, which are in general of higher type and of Cenozoic origin and radiation (hence *Ceneutheria* Osborn).

(*Clænodon protogonoides*). Edentata-Tæniodonta, with enameled teeth, 2 families: (1) Stylinodontidæ, (2) Conoryctidæ.

Summary of genera and species.

	Genera.	Species.
Archaic Triassic mammals	3	5
Archaic Cretaceous mammals	15	24
Total archaic mammals	18	29
Modernized or distinctively Tertiary mammals	0	0

The Puerco is a fauna wholly of Mesozoic origin, and mostly destined to disappear; not a single representative or ancestor of any existing order of Tertiary mammals is certainly known. Cope's opinion[a] that many of these mammals were ancestral to the modernized mammals lacks direct confirmation at present. Other paleontologists, however, are inclined to connect certain of the creodont families with the modern Carnivora. These and other ancestral connections may be demonstrated in future.

Negatively, therefore, the Puerco is distinguished by the absence of primates, rodents, true carnivores, specialized insectivores, artiodactyls, perissodactyls, etc.[b] This generalization has hardly less important bearings on paleogeography than on paleozoology.

2. TORREJON FORMATION; PANTOLAMBDA ZONE.

(Fig. 1; Pl. I.)

HOMOTAXIS.

North America.—1, Torrejon formation (300 feet), continuous with Puerco formation, San Juan basin, northwestern New Mexico. 2, A portion of the Fort Union formation, Montana (Douglass,[c] Farr).

Europe.—Thanétien or Cernaysien. Homotaxis with Europe is indicated by the common presence in France and North America of similar stages of evolution in representatives of 3 families, namely, (1) Plagiaulacidæ, (2) Arctocyonidæ, and (3) Mesonychidæ-Triisodontinæ. Other identifications are very uncertain.[d]

FAUNA.[e]

Like the Puerco, this is almost exclusively a Mesozoic fauna, destined to become extinct during the Eocene. The known excep-

[a] The opposite theory of the nonancestry of the Puerco-Torrejon to the modern fauna was developed by the writer, in Rise of the Mammalia in North America: Proc. Am. Assoc. Adv. Sci., vol. 42, 1893 (1894), p. 214. See also Ten years' progress in mammalian paleontology: Compt. Rend. 6e Cong. intern. zoologie, Berne, 1904, pp. 86–113.

[b] Certain incompletely known mammals (e. g., species of *Mioclænus* and *Pentacodon*, of the Oxyclænidæ and Mixodectidæ) may prove to be Insectivora.—W. D. M.

[c] Douglass, Earl, A Cretaceous and lower Tertiary section in south-central Montana: Proc. Am. Philos. Soc., vol. 41, pp. 207–224. Also, New vertebrates from the Montana Tertiary: Ann. Carnegie Museum, vol. 2, 1903, pp. 145–200.

[d] Osborn, H. F., A review of the Cernaysian Mammalia: Proc. Acad. Nat. Sci. Philadelphia, May 6, 1890, pp. 51–62.

[e] Matthew, W. D., A revision of the Puerco fauna: Bull. Am. Mus. Nat. Hist., vol. 9, 1897, pp. 259–323. (See Appendix to this volume, p. 91.)

tions in surviving types are the pro-Carnivora-Miacidæ, which first appear at this stage. Others will be discovered.

Mammals of larger size, mostly evolved from the Puerco mammals. Last survivors of the Multituberculata. Edentata-Tæniodonta of larger size. Of archaic Ungulata, 2 orders and 3 families: (1) Condylarthra-Phenacodontidæ, (2) Amblypoda-Periptychidæ, (3) Amblypoda-Pantolambdidæ. Of the latter, *Pantolambda* is supposed to be ancestral to the Coryphodontidæ of the Wasatch. Carnivora-Creodonta, 4 families: (1) Mesonychidæ-*Triisodon* and *Dissacus*, (2) Oxyclænidæ, (3) Arctocyonidæ, (4) pro-Carnivora-Miacidæ. The primate-like *Indrodon* and aberrant *Mixodectes* are of unknown relationships; they are possibly Insectivora.

Summary of genera and species.

	Genera.	Species.
Archaic Triassic stock	3	4
Archaic Cretaceous stock	21	36
Total archaic stock	24	40
Modernized Tertiary stock	1	1

II. SECOND FAUNAL PHASE.

First modernization—Invasion of the archaic by the modern fauna—South American land connection interrupted—Close faunal connection with western Europe—Initial elimination of the archaic fauna in competition with the modern.

In the period of the deposition of the Wasatch formation, independent deposits were formed in western Wyoming, northern Wyoming, and New Mexico. A momentous change occurs, namely, the sudden modernization of the mammalian fauna of the Mountain Region.

In the San Juan basin of northwestern New Mexico, after a barren deposition interval of only a few hundred feet between fossiliferous Torrejon and Wasatch levels (see fig. 1), there appear representatives of ancestors of 4 or 5 modern orders, including 11 new families, 2 of which persist to the present time. European paleontologists usually attribute the origin of this modernized fauna to North America, but this is without evidence; it is certain that it originated neither in South America nor in Africa. There remain four possible sources; these animals may have entered the central Mountain Region by migration (1) from the Great Plains Region, or (2) from the more northerly American Mountain Region, or (3) from the northerly Eurasiatic Region, or (4) from the northerly American-Asiatic land mass.

In the writer's judgment, the simultaneous and sudden appearance in North America, latitude 40°, and in western Europe, latitude 50°, of a similar fauna favors the fourth theory, namely, that of the intermediate or North American-Asiatic or Holarctic origin of this

fauna. It must be remembered that while there is no evidence of a "Holarctica," or north polar continent, similar to the "Antarctica" in the south, there was certainly a great American-Asiatic land mass to the north, of temperate climate, favorable to the evolution of mammalian life. The vast region between parallels 50° and 70° is also a terra incognita until the mid-Pleistocene. There is every reason to believe that even to the north this region was through the whole pre-Pleistocene Tertiary highly favorable to mammalian life, otherwise the faunal continuity between Europe and western America could not have been sustained by constant intermigration. Wortman[a] and others have especially advocated the theory of a northerly or Arctic Circle land mass as a source of evolution and southward migration.

The actual origin of this modernized fauna which suddenly appears in North America and Europe is, however, hypothetical and will not be determined until Eocene fossil mammal beds in northern portions of America and Asia shall have been discovered.

LOWER EOCENE (EUROPE, ÉTAGES SPARNACIEN, YPRÉSIEN).

3. WASATCH FORMATION; CORYPHODON ZONE.

(Figs. 1–4; Pl. I.)

HOMOTAXIS.

North America.—1, Typical Wasatch (in part), Knight formation, Veatch (1,750 feet), western Wyoming. 2, Wasatch near Black Buttes, Washakie basin, Wyoming. 3, Wasatch of the San Juan basin of northern New Mexico (1,500 feet). 4, Wasatch of the Bighorn Basin of northern Wyoming (2,391 feet, Loomis). 5, Lower portion of the Huerfano formation near Spanish Peaks, Colorado.

South America.—No South American affinities are known.

Europe.—Strong affinities with the fauna of the étage Sparnacien and especially with that of the étage Yprésien (Londinien) of France are found in the evolution of the archaic and in the sudden appearance of the modernized Mammalia of this period.

The Sparnacien (Soissonais inférieur) includes in France the deposits of Soissons, Meudon, and Vaugirard; in England, the Woolwich beds and lower London clay. The Yprésien (or Soissonais supérieur) of France includes deposits of Ay and Cuis. It is in this stage that the European modernization becomes marked by the sudden appearance of Primates, Rodentia, 2 families, Perissodactyla-Lophiodontidæ and Artiodactyla-Dichobunidæ. The Lutétien inférieur of France corresponds approximately with the American upper part of the Wind River.

---

[a] Wortman, J. L., Studies of Eocene Mammalia in the Marsh collection, Peabody Museum; Part II, Primates: Am. Jour. Sci., June, 1903, 4th ser., vol. 15, pp. 419–436.

The general parallelism of France, England, and North America is indicated (1) by the common presence in this period of similar

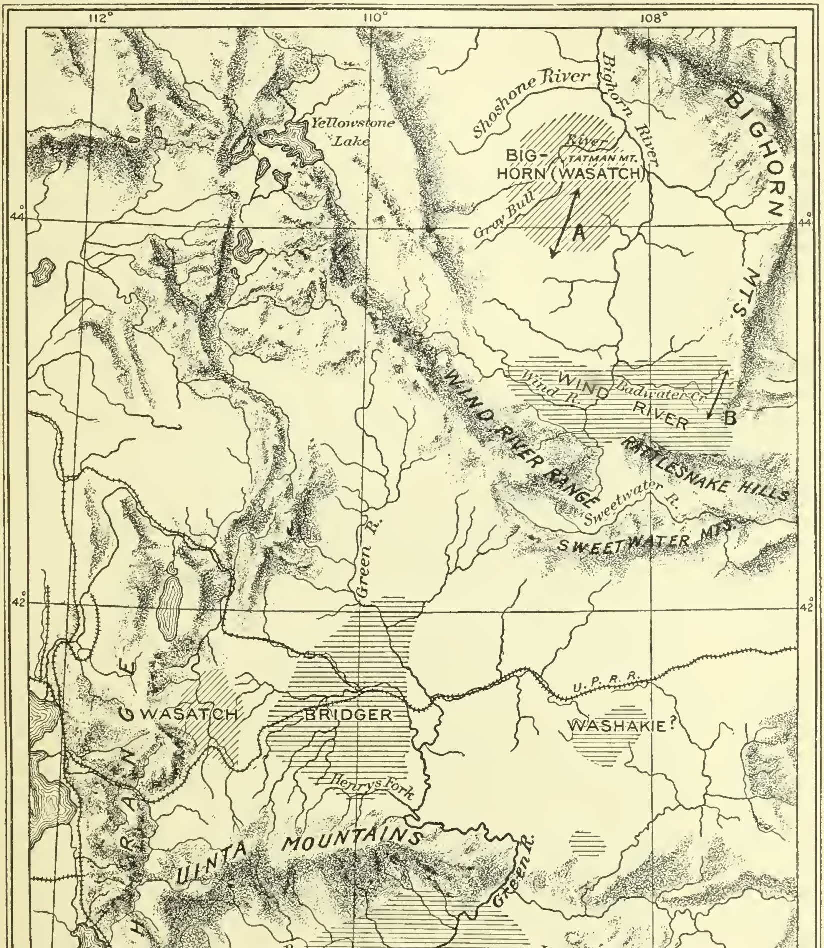


FIG. 2.—Map of southwestern Wyoming and northern Utah, showing partial areas of the Wasatch Wind River, Bridger, and Uinta formations. Extensive areas of the Wasatch are purposely omitted. A, B, lines of sections by F. B. Loomis.

stages in archaic mammals—among Creodonta: Mesonychidæ, Palæonictidæ, ?Arctocyonidæ, and Oxyænidæ; among Amblypoda: Cory-

phodontidæ; (2) by the sudden appearance of the four Tertiary orders, (*a*) Perissodactyla-Equidæ[a] and -Lophiodontidæ, (*b*) Artiodactyla, (*c*) Primates, and (*d*) Rodentia.

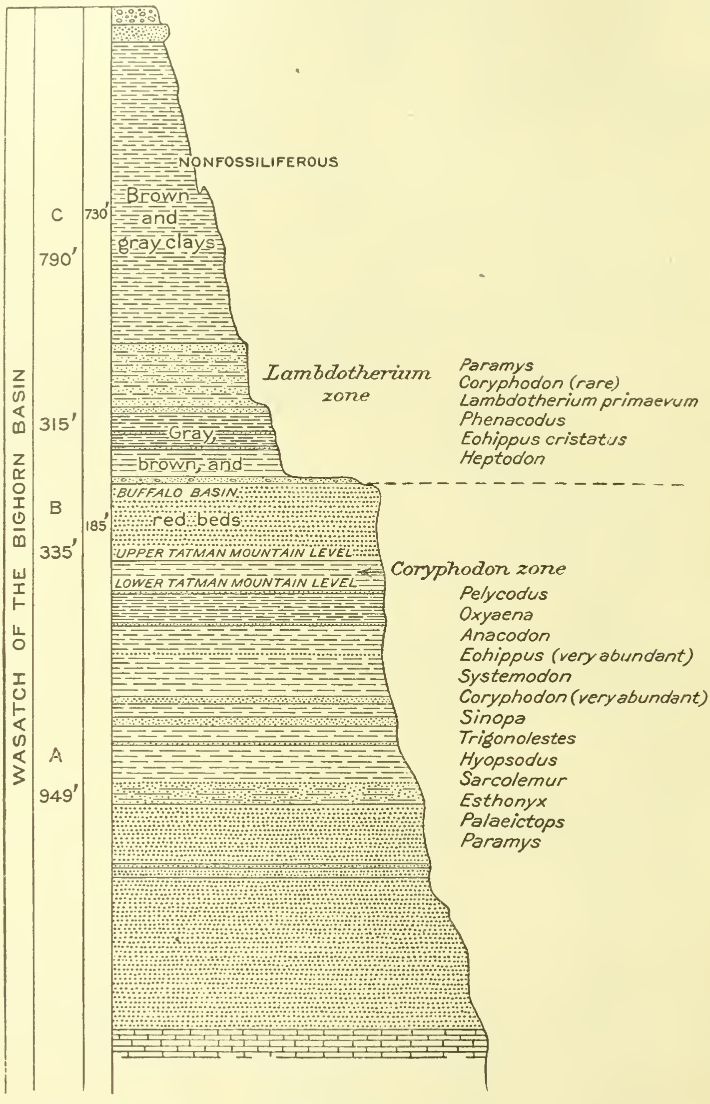


FIG. 3.—Composite columnar section of the Wasatch formation of Bighorn Basin, compiled from sections by F. B. Loomis. See section A, fig. 2. Total thickness 2,391 feet.

Other faunal identifications with Europe are premature. With the exception of the archaic and modern families above listed, the European families and subfamilies are different from the American so far

[a] The Equidæ of the Sparnacien are more primitive than the oldest Wasatch species.

as known. H. G. Stehlin[a] supports the writer's opinion that Rütimeyer was too prone to identify European with American genera;

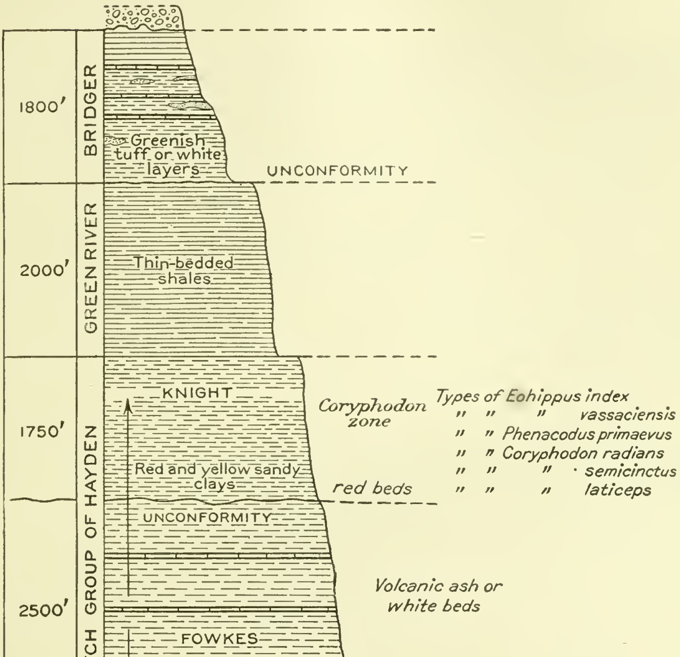


FIG. 4.—Columnar section showing the relations of the typical Wasatch section, including the Knight formation (near Knight, Wyo.), or *Coryphodon* zone, to the overlying and underlying formations. After Veatch, 1907.

this removes the American resemblances supposed to exist in the Egerkingen fauna, which now proves to be of middle Eocene (Luté-

[a] In letter dated July, 1906, Doctor Stehlin states that he is himself engaged in the study of migrations. He, too, finds strong evidence (1) for a lower Eocene connection between America and Europe, (2) for a very decided separation during the middle and upper Eocene, and (3) for a renewed connection in the Oligocene and a great Oligocene faunal interchange. These are substantially the views adopted in the present paper.

tien) age. The supposed "americoids," *Calamodon, Phenacodus, Euprotogonia, Hyopsodus, Pelycodus,* etc., are all European animals.

FAUNA.[a]

The Wasatch fauna consists of a nearly equal or half-and-half mingling of (1) archaic mammals, including 9 families which evolved from the Puerco-Torrejon fauna, with (2) ancestors of the modernized mammals, including 11 families. From this stage onward we have to consider these two great elements in the fauna separately.

Summary of genera.

Persistent Triassic mammals	0
Other archaic[b] mammals	22
Modernized mammals	16
	38

There is thus at this period a slight predominance in number of the archaic mammals over the modernized, but the individual archaic mammals greatly predominate in size.

The surviving archaic or Puerco-Torrejon mammals.—Some of these mammals, such as *Coryphodon,* are of large size. The Multituberculata disappear. Of the Edentata-Tæniodonta, 3 genera of the Stylinodontidæ. Of the archaic ungulates, 2 orders and 3 families are represented: (1) Amblypoda-Coryphodontidæ, as successors to the Pantolambdidæ; (2) Condylarthra-Phenacodontidæ; (3) Condylarthra-Meniscotheriidæ. Of the Creodonta-Carnivora there occur 5 families, namely, Palæonictidæ, Oxyænidæ, Hyænodontidæ, Mesonychidæ, and Arctocyonidæ; 4 of these families also occur in France.

The Tertiary or modernized mammals.—These mammals are mostly of small size, including the successors of the supposed Torrejon pro-Carnivora-Miacidæ, a family which now branches out into several genera. No other Carnivora. True Primates, 2 families. Rodentia, 1 genus, *Paramys* with sciuroid teeth. Insectivora, 2 or 3 families, one of doubtful affinity. Among Ungulata-Perissodactyla, 3 families, Equidæ, Tapiridæ, Lophiodontidæ. Among Ungulata-Artiodactyla, 1 family. There are thus 11 families among the modernized mammals, only two of which (Equidæ and Tapiridæ) persist to the present time.

---

[a] Osborn H. F., and Wortman, J. L., Fossil mammals of the Wasatch and Wind River beds: Bull. Am. Mus. Nat. Hist., vol. 4, 1892, pp. 81-147.

Loomis, F. B., Origin of the Wasatch deposits: Am. Jour. Sci., May, 1907, 4th ser., vol. 23, pp. 356-364. See Appendix, p. 91.

[b] See footnote, p. 33.

3a. WASATCH OF THE BIGHORN BASIN.

(Figs. 1–3; Pl. I.)

Loomis[a] examined the Wasatch of the Bighorn Basin when the question of epicontinental versus lake deposition was uppermost in the minds of all. By a careful analysis of the fauna, combined with an exact study of the geologic section, he dismisses the lake theory entirely. Geologically, as displayed in fig. 3, the section is 2,391 feet thick, divided into lower, middle, and upper levels, all showing flood-plain rather than eolian characteristics, but indicating different rates of deposition and consequent longer or shorter exposure of the deposits to the sun and air. Only the middle or red beds are decidedly fossiliferous, and they seem to have been exposed longest to the air, leaving the bones of terrestrial animals on the flats; they contain the typical Wasatch, *Coryphodon* and *Eohippus* fauna. Occasionally truly aquatic animals, such as crocodiles, fishes, and turtles, becoming stranded or inclosed in lagoons far from the river, mixed their remains with those of the land animals. Loomis's approximate analysis of the natural habitat of the total vertebrate fauna is: Aerial, 3 per cent; terrestrial and arboreal, 77 per cent; amphibious, 12 per cent; aquatic, 10 per cent.

Remains of *Eohippus*, typical of a plains or partly open country, alone make up 32 per cent of the total fauna. To this should be added the Perissodactyla-Lophiodontidæ-Helaletinæ (*Heptodon*), and some of the Condylarthra-Phenacodontidæ, which are very light-footed forms. The primitive Titanotheriidæ (*Lambdotherium*) of the period may have been hard-ground dwellers, because their feet are more slender and contracted than those of the modern tapir, while the Amblypoda-Coryphodontidæ were certainly marshy-land dwellers and perhaps partly amphibious or stream dwellers, although this is far from demonstrated. As to relative age, Loomis fixes very positively the typical American Wasatch fauna, or chief *Eohippus* and *Coryphodon* zones of Tatman Mountain, as only 100 to 200 feet below the beds of the Buffalo basin. The deposits in the Buffalo basin show, 1,000 feet below the summit, a decided approach if not actual synchronism to the lower deposits of the Wind River valley in the presence of *Lambdotherium* and in the progressive evolution of the Equidæ. Thus there is a prolonged time overlap between the deposits of the Bighorn and those of Wind River. (See fig. 1, p. 23.)

[a] Am. Jour. Sci. May, 1907, 4th ser., vol. 23, pp. 356–364.

III. THIRD FAUNAL PHASE.

Absence of fresh Eurasiatic or northern migration—Continuation of similar environmental conditions—Descendants of the archaic and modernized mammals slowly evolving and competing with one another during the lower and middle Eocene—Gradual elimination of the archaic mammals—Gradual divergence from the fauna of western Europe, and little evidence of faunal interchange—Establishment of North American Ungulata-Artiodactyla.

First, as to progressive divergence from Europe, it appears that by the middle and upper Eocene stage there were 13 non-European families of mammals in America and 11 non-American families of mammals in Europe, as against 4 European-American families common to the two regions. This independent and divergent evolution was not sufficiently emphasized until suggested by the writer in 1899.[a] It points to the existence of prolonged geographic or climatic barriers between the two continents.

Second, as to the continuously uniform conditions in the Mountain Region, Matthew has especially called attention to the prolonged uniformity of life, alike as to families, genera, and species, throughout the Wasatch, Wind River, Huerfano, and lower Bridger depositions. To this uniformity may be added the *Uintatherium* zone of the Bridger and Uinta basins; in other words, the uniformity extended from the lower to the upper Eocene. The changes are those of modification and development rather than of breaks in the balance of nature by migration and extinction.

Our conclusions are as follows: (1) Environment: Uniform and favorable environmental conditions prevailed during this long period in the Mountain Region, with the competition and balance of nature somewhat in favor of the modernized families, all of which persisted, while 5 families of the archaic mammals disappeared. (2) Evolution: Both the archaic (Cretaceous) and the modernized mammals increased in size and in variety; the changes are chiefly specific rather than generic. (3) Gains and losses: Two archaic families of Ungulata, Condylarthra-Phenacodontidæ and Amblypoda-Coryphodontidæ, appeared for the last time (Wind River); 1 new archaic family, the Amblypoda-Uintatheriidæ, appeared (Wind River); 2 families of archaic Carnivora-Creodonta have disappeared (Wasatch), namely, Palæonictidæ, Arctocyonidæ;[b] the progressive Carnivora-Miacidæ are represented by 5 genera; 1 new family of Ungulata-Perissodactyla

[a] Osborn, H. F., Correlations between Tertiary mammal horizons of Europe and America, etc.: Ann. New York Acad. Sci., vol. 13, 1900, p. 18. "Fourth, the Ligurien is widely distinct faunally from the American upper Eocene or Uinta, with which it has been heretofore paralleled. At no period of the Tertiary were the Nearctic and Palæarctic faunæ so widely separated. In fact, a much wider gap exists between western America and Europe in the upper Eocene than in the preceding lower and middle Eocene or in the succeeding lower Oligocene."

[b] Matthew considers that the Arctocyonidæ should not be placed among the archaic mammals, but rather that they represent an early branch of the Pro-Carnivora.

appeared (Wind River), namely, the Titanotheriidæ, possibly entering from the Great Plains Region to the east; 1 new family related to the Edentata-Dasypoda, or armadillos, appeared (Bridger), probably from the southern Great Plains Region and originally of South American origin before the Cretaceous land connection was interrupted.

LOWER TO MIDDLE EOCENE (EUROPE, ÉTAGES YPRÉSIEN, LUTÉTIEN INFÉRIEUR).

4. WIND RIVER FORMATION;[a] LAMBDOTHERIUM AND BATHYOPSIS ZONES.

(Figs. 1–2, 5; Pl. I.)

HOMOTAXIS.

North America.—1, Wind River formation, Hayden, of northern Wyoming (1,200–1,400 feet). 2, Upper half of the Wasatch of the Bighorn Basin. 3, Lower part of Huerfano formation, Hills, of Colorado (200? feet).

Europe (provisional).—The lower part of the Wind River is partly equivalent to the Yprésien of France. The upper part of the Wind River is approximately equivalent to the Lutétien inférieur of France.

FAUNA.[b]

The mammals of the Wind River deposition are less fully known than those of either the Wasatch or the Bridger. So far as these three faunæ can be separated at present, the lower Wind River presents closer affinities to the Wasatch, while the upper Wind River presents closer affinities to the Bridger. The balance of life between the archaic and the modernized mammals continues to be nearly even.

Summary of genera.

Archaic or Cretaceous mammals	17
Modernized or Tertiary mammals	17
	34

Faunal sequence to the Wasatch.—Partial faunal continuity with, and partial sequence in time to, the Wasatch is sustained (1) by the presence of 19 genera in common with the Wasatch, (2) by the rarity or absence of a few Wasatch animals, (3) by the occurrence of more advanced (or post-Wasatch) stages of evolution in a large number of descendants of animals which persist from the Wasatch, (4) by

[a] This section has been revised by Prof. F. B. Loomis, the most recent explorer of this basin.

[b] Loomis, F. B., Origin of the Wasatch deposits: Am. Jour. Sci. May, 1907, 4th ser. vol. 23, pp. 356–364. Cope, E. D. The badlands of the Wind River and their fauna. Am. Naturalist, vol. 14, 1880, pp. 745–748. See Appendix, p. 91.

the significant fact that some of the more advanced stages occur in the base of the Wind River deposition, (5) by the introduction of true primitive Dinocerata or uintatheres, of primitive titanotheres, of new Primates, which are not found in the Wasatch, and of more highly specialized Tæniodonta (*Stylinodon*).

The writer's conclusions at present are (1) that the base of the Wind River, or Wind River A, began to be deposited during the upper stage of the Wasatch deposition of the Bighorn Basin (see p. 41),

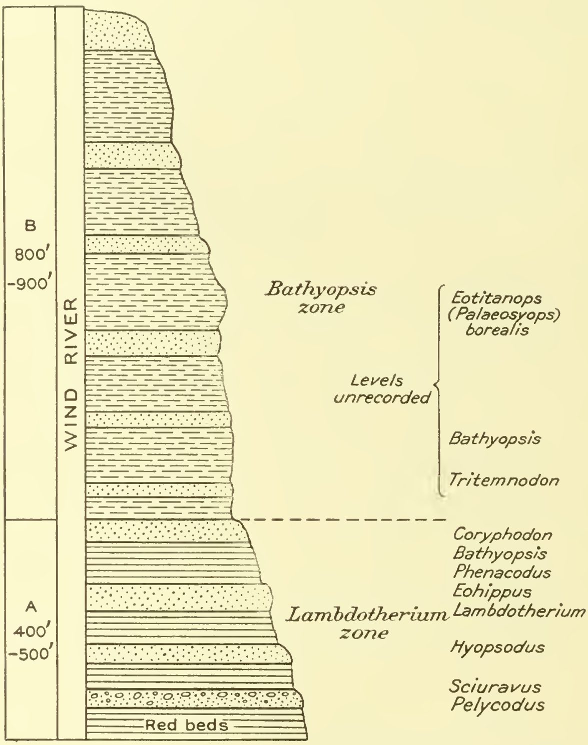


FIG. 5.—Columnar section of the Wind River basin, based on the descriptions of Hayden and Loomis. The horizontal banding of the red and greenish-gray beds in Wind River B is very regular. The occurrence of *Eotitanops* and *Bathyopsis* in the upper Wind River is not certainly recorded.

and was thus contemporaneous with most of the upper fossil-bearing strata of the Bighorn Basin Wasatch; (2) that positive evidence of an overlap may be derived from the study of the faunæ; (3) that the *Lambdotherium* zone occurs in each.

Geologic divisions.—Hayden's exploration of 1859–60, as reported in 1869,[a] afforded materials for the first complete section we have of the Wind River Tertiaries. His "lower division," of 400 to 500

[a] Geol. Rept. Explor. Yellowstone and Missouri Rivers, by F. V. Hayden, assistant [to Col. William F. Raynolds, U. S. Engineers], Washington, 1869.

feet, which we may designate Wind River A, is largely fossiliferous and has yielded most of the important forms found in successive explorations by Wortman[a] (1891), Granger (1905), and Loomis[b] (1907). Hayden assigned 1,200 feet to an "upper division," which we may designate Wind River B. This is now believed to contain fossils of a higher type, although the field records are not quite clear and fossils are scarce.

Preliminary faunal divisions.—(A) Wind River, lower 500 feet, red beds. *Lambdotherium* zone. Contains *Coryphodon*, *Phenacodus*, *Eohippus*, *Lambdotherium*, etc. (B) Wind River, upper 800 feet. *Bathyopsis* zone. Contains *Coryphodon*, *Phenacodus*, also *Bathyopsis* *Palæosyops borealis* (= *Eotitanops*).

The B stage approximates the middle Eocene, or Lutétien inférieur of France (Argenton, the older Lissieu and older Egerkingen fissure-formation faunæ), and the Bracklesham of England.

General faunal characters of the Wind River.—Since the faunal levels which undoubtedly distinguish Wind River A and B have not yet been clearly separated, we must consider the fauna chiefly as found on the lower levels, or red beds. First it must be made clear that the Wind River, as compared with either the Wasatch or the Bridger, is a relatively barren formation and has not been so fully explored.

Archaic or Cretaceous fauna: Of the ancient fauna the Creodonta are represented by 4 families, the members of which are incompletely known. Of these the genera (*a*) *Hapalodectes* and *Pachyæna* (Mesonychidæ), (*b*) *Tritemnodon* (Hyænodontidæ), and *Oxyæna* (Oxyænidæ) are somewhat more advanced than Wasatch forms; (*c*) *Limnocyon*, a primitive, and *Patriofelis*, a specialized member of the Oxyænidæ, appear for the first time, animals which are very characteristic of the Bridger; (*d*) *Anacodon* represents the Arctocyonidæ.

Among the Tillodontia the Wasatch genus *Esthonyx* persists, and among Tæniodonta (Edentata?) the Bridger genus *Stylinodon* first appears. The Insectivora are undoubtedly represented in *Palæictops* (Leptictidæ), *Palæosinopa* (Pantolestidæ), and possibly also by several species of *Hyopsodus*, all in more advanced evolution stages than those in the Wasatch, but still distinct from the Bridger species. It is noteworthy that *Hyopsodus* attains its largest size at this time. The reported existence by Cope of Cheiroptera is an error.

The Condylarthra-Phenacodontidæ diminish and disappear. The Amblypoda-Coryphodontidæ also diminish and disappear, being replaced by the Amblypoda-Uintatheriidæ. Of Carnivora-Creodonta, the family Arctocyonidæ is represented by *Anacodon* (vide

[a] Wortman, J. L., Bull. Am. Mus. Nat. Hist., vol. 4, 1892, pp. 135–144.
[b] Loomis, F. B., Am. Jour. Sci., 4th ser., vol. 23, 1907, pp. 356–364.

Loomis); the Palæonictidæ are represented by doubtfully referred specimens in the Wind River and lower Huerfano; the 3 certainly surviving creodont families are the Mesonychidæ, Oxyænidæ, and Hyænodontidæ. The Edentata-Tæniodonta are represented by *Stylinodon;* the Tillodontia by *Esthonyx.* A supposed marsupial, *Peratherium comstocki,* is reported by Cope and Loomis.

Modernized fauna: Among the modernized forms the forest-living primates first deserve notice: (*a*) Of the animals of larger size the Notharctidæ include *Pelycodus,* surviving from the Wasatch and continued into the lower Bridger; also *Notharctus,* a monkey very plentiful in the Bridger, now appearing for the first time; (*b*) the specialized Anaptomorphidæ recur; (*c*) the doubtful primates Microsyopidæ are also found.

The Rodentia are represented by the rather abundant *Paramys* and somewhat more rare *Sciuravus.* Among Insectivora, 3 families are known, namely, Leptictidæ (*Palæictops*), and the recently referred families Hyopsodontidæ and Pantolestidæ. The pro-Carnivora-Miacidæ, now become more diversified, including the genera *Didymictis, Vulpavus,* and *Miacis,* all found in the Wasatch, which recur here in slightly larger and more progressive forms. These animals resemble the Canidæ in dental structure and the Procyonidæ in other points. The Bridger genera *Viverravus* and *Oödectes* appear here for the first time.

Of modernized Ungulata-Perissodactyla there are now 4 families. It is noteworthy that all are represented by light-limbed slender-footed forms, pointing to rather dry-land conditions in this region at the time. (*a*) The Equidæ are represented by the persisting Wasatch forms still known as *Eohippus* because a rudimentary fifth digit still persists in the pes and there is little advance in dentition. (*b*) Members of the Tapiridæ have not been found, but they undoubtedly existed. (*c*) The Lophiodontidæ are represented by *Heptodon.* (*d*) The newly appearing Titanotheriidæ are represented by 2 genera and 3 species.

The distinctive forms of titanotheres found in the Wind River are:

Lower part of Wind River, *Lambdotherium popoagicum,* of about the height of a water chevrotain (*Dorcatherium aquaticum*).

?Upper part of Wind River, *Eotitanops borealis,* of about the height of a wart-hog (*Phacochœrus africanus*).

?Upper part of Wind River, *Eotitanops brownianus,* of about the height of a young pig.

Of these animals the *Lambdotherium* occurs plentifully only in the upper Wasatch deposits, in the lower part of the Wind River, and in the Huerfano formation of southern Colorado. Nothing at present is known in the Wasatch which could stand ancestral to it, nor is any

Bridger genus known which could be directly descended from the species *L. popoagicum*.

Of Ungulata-Artiodactyla *Trigonolestes* survives from the Wasatch.

WIND RIVER A; LAMBDOTHERIUM ZONE.

Period of lower deposition.—Wortman[a] concluded on his second visit (1891) that the lower Wind River is absolutely distinct from the Wasatch of the Bighorn Basin and belongs to a succeeding deposition. He supposed that the Wind River country was above water during the laying down of the Wasatch sediments, and that some time after the close of the Wasatch a lake was formed on the site of the present Wind River basin. Loomis[b] (1907) regards the Wind River formation as epicontinental, fluviatile, and flood-plain, like the Wasatch, and slightly subsequent in the beginning of its deposition.

General characters.—A total thickness of 400 to 500 feet near the sources of Wind River. Readily distinguished geologically by horizontally alternating bands of bright-red and gray fossil-bearing shales and sandstones containing *Coryphodon*, turtles (*Trionyx*), crocodiles (*Crocodilus*), Lacertilia-Anguidæ (*Glyptosaurus*), etc. The conglomerates, indicating rapid stream or river invasions, are barren. The writer is indebted to Professor Loomis for the section (fig. 5, p. 44) and for his observations on stratigraphic distribution.

Fauna.—The chief part of the Wind River fauna listed above is from these red beds. In the lower red beds are found *Coryphodon*, *Eohippus*, *Lambdotherium*, and several species of *Hyopsodus;* among primates, *Notharctus* and *Pelycodus*. The American Museum collections of 1905, nearly all from the red beds, exhibit a closer degree of affinity to those of the upper Wasatch than is found in specimens from the upper beds. The Amherst collections include from these beds *Bathyopsis*, the earliest known member of the Dinocerata.

WIND RIVER B; BATHYOPSIS ZONE.

Period of upper deposition.—The upper levels, or Wind River B, are naturally to be compared with Bridger A, but unfortunately too few fossils have as yet been found to afford such a basis of correlation.

Hayden (1869) described these beds as consisting of 800 to 900 feet of ferruginous, coarse-grained sandstones, alternations of sandstones and marls, light sandstones, friable sandstones, and indurated marls. They are probably in large part of volcanic-dust origin. Some of these strata indicate great disturbances in the water during their

[a] Wortman, J. L., Fossil mammals of the Wasatch and Wind River beds: Bull. Am. Mus. Nat. Hist., vol. 4, 1892, pp. 143–144.

[b] Loomis F. B , Origin of the Wasatch deposits: Am. Jour. Sci., 4th ser., vol. 23, 1907, pp. 356–364.

deposition. Altogether the conditions were unfavorable, perhaps prohibitive, for the deposition of fossils.

Fauna.—Although not certainly recorded, it appears probable that Wind River B contains *Eotitanops borealis*, the second known stage in the evolution of the Titanotheriidæ, the first known stage being *Lambdotherium primævum* Loomis of Wind River A.

4a. HUERFANO FORMATION; LAMBDOTHERIUM AND ?UINTATHERIUM ZONES.

HOMOTAXIS.

North America.—1, Huerfano formation of Hills, 1888 (800–1,000 feet, Wortman). 2, Wind River (*Lambdotherium* zone) in part. 3, Lower part of Bridger formation.

The only middle Eocene deposit east of the Rocky Mountains is that of the Huerfano River basin of southern Colorado (see Pl. I), first described by Hills[a] in 1888, explored by the writer and Wortman in 1897, and described by the writer.[b] The basin opens into the plains immediately north of the famous Spanish Peaks. The sediments described below as marls, clays, shales, etc., will very probably prove to be of volcanic-dust origin.

The writer's present conclusion as to the age of this formation is that it began during the Wind River and continued without a break into the period of the lower Bridger formation.

LOWER PART OF HUERFANO FORMATION; LAMBDOTHERIUM ZONE.

(Homotaxis, Wind River.)

Wortman explored the immediately underlying levels to the east of Gardner, previous explorations having been made to the north and west, and was surprised to find a fauna containing none of the forms characteristic of the Bridger level (as chiefly found by Hills), but distinguished as of Wind River age by the presence of *Coryphodon*, *Lambdotherium*, *Oxyæna*, *Trigonolestes*, and other lower Eocene forms. Wortman[c] says:

> These beds of the lower division are indistinguishable, so far as their general appearance and lithological characters are concerned, from those of the upper level. The fossils occur apparently in a single stratum not exceeding 10 or 15 feet in thickness, and not more than 30 or 40 feet from the base of the formation. They underlie the beds of the upper division with perfect conformity, and there is at present no means of determining exactly where the one ends and the other begins. * * * The exact locality from which the greater number of the fossils of the lower beds were obtained is Garcias Canyon, about 1½ miles south of Talpa or the mouth of Turkey Creek.

---

[a] Hills, R. C., 1888.

[b] Osborn, H. F., The Huerfano Lake basin: Bull. Am. Mus. Nat. Hist., vol. 9, 1897, p. 251.

[c] Wortman, J. L., Geological and geographical sketch of the Bighorn Basin. In Osborn, H. F., and Wortman, J. L., Fossil mammals of the Wahsatch and Wind River beds: Bull. Am. Mus. Nat. Hist., vol. 4, 1892, pp. 135–144.

The fauna, as originally determined and subsequently (February, 1906) reexamined by Matthew from the very small American Museum collection, is as follows:

Lower Huerfano fauna and equivalents.

[×=species represented; (×)=genus represented.]

	Lower Huerfano.	Wasatch.	Wind River.	Bridger.
Coryphodon sp. cf. ventanus	×	....	×	....
Lambdotherium popoagicum	×	....	×	....
Eohippus (Pliolophus) sp	×	(×)	×	....
?Phenacodus cf. wortmani	(?)	×	×	....
Trigonolestes sp	×	×	×	....
Oxyæna huerfanensis	×	(×)	....	....
Didymictis cf. altidens	×	(×)	×	....
Viverravus cf. dawkinsianus	×	×	×	(×)
?Didelphodus	(?)	×	....	....
Hyopsodus, large sp	×	×	×	×

The *Eohippus* is more advanced than anything in the Wasatch, but distinctly more primitive than the most primitive *Orohippus* of the Bridger in our collections. The lower part of the Huerfano is, on this showing, homotaxial with a portion of the Wind River.

UPPER PART OF HUERFANO FORMATION; ?UINTATHERIUM ZONE.

(Homotaxis, lower (?) Bridger.)

West of Huerfano Canyon the so-called variegated marls, clays, soft shales, and sands aggregate only 800 to 1,000 feet in thickness, are nearly horizontal in position, and constitute the "upper series" of the typical Huerfano lake deposits of Hills. To the west of Gardner all the mammal remains were found in these sands, clays, and marls, varying from red, purple, gray, or green to yellow or whitish in color, the upper arenaceous clays containing the richest deposits. These deposits have not been examined lithologically; it is quite possible that they are largely composed of volcanic ash. Although the fossils are nowhere numerous, they are all of Bridger age, namely, *Palæosyops*, *Hyrachyus*, *Tillotherium*, and *Glyptosaurus*.

Upper Huerfano fuana and equivalents.

	Upper Huerfano.	Wasatch	Wind River.	Bridger.
Tillotherium sp	×	....	....	×
Paramys	×	×	×	×
Microsyops sp	×	....	×	×
Patriofelis sp. ind	×	....	....	(×)
?Hyrachyus small sp	×	....	....	×
Amblypoda, [a] genus of?	(×)	....	....	....

[a] The Amblypoda are represented by a tibia of small size which may have belonged to *Uintatherium*.

It is clear that these beds must be referred to the Bridger, not to the Wind River. The *Paramys* compares most nearly with lower Bridger species, but is too incomplete to settle its position without very careful comparisons. There does not appear to be anything else to indicate whether these beds are equivalent to lower or to upper Bridger. The *Patriofelis* is a very much smaller species than *P. ulta* of the lower Bridger or *P. ferox* of the upper Bridger. The *Tillotherium* is a characteristic Bridger animal.

MIDDLE EOCENE EUROPE, ÉTAGES LUTÉTIEN SUPÉRIEUR, BARTONIEN).

5. BRIDGER FORMATION; OROHIPPUS AND UINTATHERIUM ZONES.

(Figs. 1, 2, 6, Pl. I.)

HOMOTAXIS.

North America.—1, Bridger formation of western Wyoming (1,850 feet), including levels A, B, C, D, E. 2, Upper part of Huerfano formation of Colorado, 3, Lower beds, or *Uintatherium* zone, in Uinta and Washakie basins of northern Utah (800 feet) in part. 4, Clarno formation of Oregon, Merriam; homotaxis provisional.

Europe, provisional homotaxis.—Lower part of the Bridger approximately equivalent to Lutétien supérieur, represented by the Calcaire grossier (Paris basin), Issel, Buchsweiler, and later fissure deposits of Lissieu and Egerkingen. Upper part of the Bridger approximately equivalent to Bartonien (Calcaire de Saint Ouen, Grès de Cesséras) in part.

CHIEF CHARACTERS OF THE FAUNA.[a]

The whole vertebrate fauna, reptilian and mammalian, of this period is better known than that of any of the other Eocene phases. The mammalian summary is as follows:

Summary of genera.

Archaic Cretaceous mammals	32
Modernized Tertiary mammals	45
	77

A marked numerical predominance, in the ratio of 4 to 3, of the modern over the archaic genera of mammals. A single South American mammal appears, the primitive armadillo *Metacheiromys*, related to the Dasypoda. Affinities with western Europe are very

[a] See Appendix, p. 91.

slight indeed. Independent evolution both of the surviving archaic and of the modern American lower Wasatch stock, with no evidence of fresh Eurasiatic migrations. Establishment of certain characteristically American families of mammals.

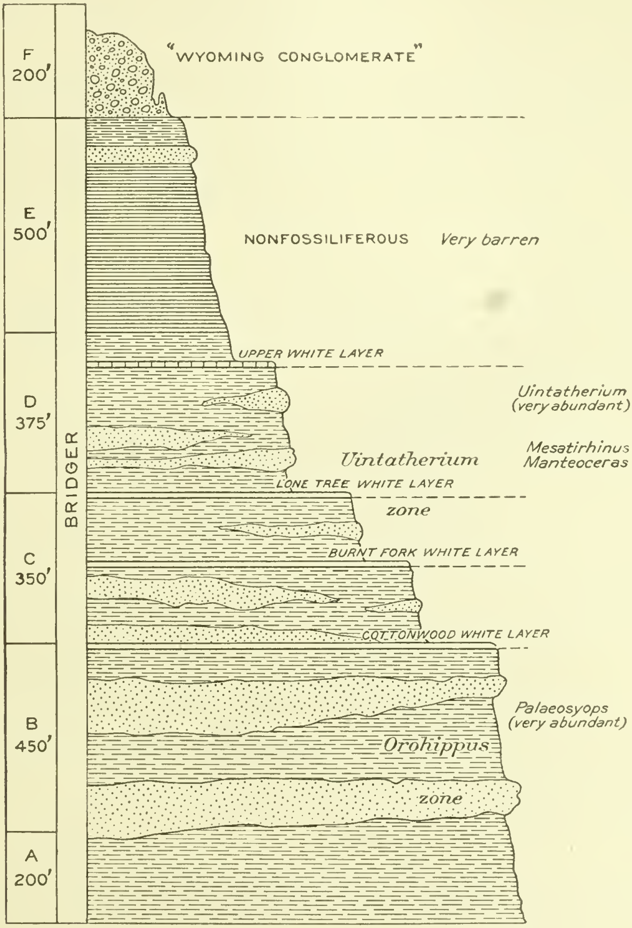


FIG. 6.—Columnar section of the Bridger formation, Henrys Fork, western Wyoming. After studies by Matthew and Granger, 1902.

Preliminary faunal divisions.—The Bridger has been separated (Matthew, Granger) into four distinct faunal levels, A–D, marked by distinct specific stages and generic stages, also by the appearance and disappearance of certain types.

1, Lower part of Bridger, levels A–B. *Orohippus* zone. Characterized by absence of *Uintatherium*; presence of Tillodontia,

Trogosus (*?Anchippodus* [a]); Perissodactyla-Equidæ, *Orohippus;* Carnivora, *Oödectes, Vulpavus.*

2, Upper part of Bridger, levels C–D. *Uintatherium* zone. Characterized by presence of *Uintatherium;* Perissodactyla-Titanotheriidæ, *Mesatirhinus megarhinus;* Tillodontia, *Tillotherium;* and lower beds, or *Uintatherium* zone, of Uinta and Washakie basins, ?upper part of Huerfano, Colorado.

The fauna of these levels is very fully known and the levels are sharply distinguishable.

The archaic fauna [b] includes mostly mammals of larger size. As in the Wind River, the Carnivora-Creodonta include 3 families—Oxyænidæ, Hyænodontidæ, and Mesonychidæ—predaceous types rapidly increasing in size and power. Aberrant Tillodontia, 2 genera (*Trogosus, Tillotherium*), their last appearance. Edentata-Tæniodonta, 1 genus (*Stylinodon*), scarce animals, also their last appearance. Of Ungulata-Amblypoda, the Uintatheriidæ or giant Dinocerata suddenly appear in the upper Bridger, possibly from the Great Plains Region.

The modern fauna includes mammals of small and intermediate size for the most part. The pro-Carnivora, Miacidæ, rapidly multiply and diversify into 8 genera, 20 species, analogous to the modern Canidæ in tooth structure,[c] and probably drive out the smaller Carnivora-Creodonta. Primates, 2–3 families, (*a*) Notharctidæ, (*b*) Anaptomorphidæ, (*c*) ?Microsyopidæ. Rodentia more numerous and diversified; the family relationships are uncertain, but include (*a*) with sciuroid teeth, 2 genera; (*b*) with arctomyoid teeth, 3 genera. Insectivora more diversified, 4–6 families, including animals analogous to if not actually related to Erinaceidæ, Talpidæ, Soricidæ, Centetidæ, also the aberrant Pantolestidæ, ?Hyopsodontidæ, and ?Leptictidæ. Related to the Edentata-Dasypoda, *Metacheiromys*, 2 species. Ungulata-Perissodactyla flourishing, 5 families, namely: (*a*) Equidæ numerous, 9 species; (*b*) Lophiodontidæ, 3 genera; (*c*) Tapiridæ, 1 genus; (*d*) Titanotheriidæ, 4 genera; first appearance of the (*e*) Rhinocerotoidea-Hyracodontidæ, 3 genera. Ungulata-Artiodactyla still of small size, but diversified into 7 genera, including primitive Selenodonta and Bunodonta.

---

[a] *Anchippodus* Leidy is typically from New Jersey, Shark River, Monmouth County. See Proc. Acad. Nat. Sci. Philadelphia, October, 1868, p 232.

[b] See Appendix, p. 91.

[c] Matthew observes, as to the affinities of these animals: "They do not make any approach to the modern Canidæ except for the dentition, which shows three groups—viverroid, cynoid, cercoleptoid. The skeleton structure varies from cercoleptoid to viverroid. The skull structure in the viverroid group is much more musteloid."

MIDDLE TO UPPER EOCENE (EUROPE, ÉTAGE BARTONIEN).

6. LATER EOCENE DEPOSITS OF WASHAKIE BASIN; UINTATHERIUM AND EOBASILEUS ZONES.

(Figs. 1, 2, 7; Pl. I.)

HOMOTAXIS.

North America.—1, *Uintatherium* zone, equivalent to the upper part of the Bridger formation and to the *Uintatherium* zone of Uinta Basin. 2, *Eobasileus* zone, equivalent to the *Eobasileus* zone of Uinta Basin. ?3, Deposits on Sage Creek, Montana.

Europe.—Bartonien of France.

HISTORY.

The Washakie Basin is a distinct area, with deposits mainly of volcanic ash, in which Hayden (1867–1869) first used Washakie as a group name comprising the lower and middle Eocene section. Subsequently he inclined to the belief[a] "that the upper series is either an extension eastward of the Bridger group or synchronous with it." It was similarly referred to by King as the Bridger group of the Washakie Basin.[b] This upper series has sometimes been referred to in paleontologic literature as the "Washakie formation."

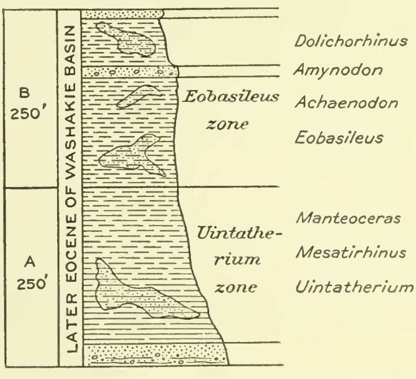


FIG. 7.—Preliminary columnar section of the later Eocene deposits of Washakie Basin, Wyoming. The upper or *Eobasileus* zone is now (1908) determined as thicker than the lower division.

FAUNA.[c]

The mammalian fauna of this stage, which has long been recognized (Osborn,[d] 1881) as in general intermediate between the Bridger and the Uinta, is sparsely known. The American Museum expedition (Osborn, Granger) of 1906 very precisely fixed its age as overlapping the summit of the Bridger and the *Uintatherium* and *Eobasileus* zones of the Uinta Basin.

Faunal divisions.—(A) *Uintatherium* zone. Brown beds (250 feet) containing *Uintatherium*. Among Perissodactyla, *Mesatirhinus mega-*

[a] Prel. Rept. U. S. Geol. Survey Terr., 1871, p. 73.

[b] King, Clarence, U. S. Geol. Explor. 40th Par., Systematic geology, 1878, p. 396.

[c] See Appendix, p. 91.

[d] A memoir upon *Loxolophodon* and *Uintatherium:* Contr. E. M. Mus. Geol. Archæol. Princeton, vol. 1, No. 1, 1881, pp. 1-14.

McMaster, John Bach, Stratigraphical report upon the Bridger beds in the Washakie Basin, Wyoming Territory, accompanied by profiles of three sections, in Osborn, H. F., A memoir, etc., as above.

rhinus and *Manteoceras* indicate equivalence to upper Bridger (C–D). (B) *Eobasileus* zone. Gray and green beds (250 feet), Haystack Mountain, containing *Eobasileus*[a] (*Loxolophodon*); Perissodactyla-Amynodontidæ; Titanotheriidæ, *Dolichorhinus cornutus;* Artiodactyla-Elotheriidæ.

The lower (A) brown beds are very extensively distributed and contain many of the same species as the upper Bridger (C–D). The upper (B) gray and green beds, probably composed largely of volcanic ash, are chiefly restricted to the great butte known as Haystack Mountain and its outlying badlands; the fauna is largely new and marks a very distinct progressive stage.

The new fauna of the Eobasileus zone.—The archaic fauna is distinguished by the final evolution of the Ungulata-Amblypoda into large, specialized Dinocerata. Carnivora-Creodonta certainly include Oxyænidæ and Mesonychidæ; the Hyænodontidæ are represented by *Sinopa.*

In regard to the modern fauna the most signal fact is the first appearance among the Perissodactyla-Rhinocerotoidea of the new family (*a*) Amynodontidæ. The (*b*) Hyracodontidæ continue from the Bridger; among (*c*) Titanotheriidæ, *Palæosyops* disappears; (*d*) Lophiodontidæ-Helaletinæ, (*e*) Tapiridæ, and (*f*) Equidæ persist. Artiodactyla are small but more diversified. Rodentia-Ischyromyidæ. Pro-Carnivora-Miacidæ. Large elotheres, *Achænodon,* occur.

UPPER EOCENE (EUROPE, ÉTAGES BARTONIEN IN PART, LUDIEN (LIGURIEN) IN PART).

7. LATER EOCENE DEPOSITS OF UINTA BASIN; UINTATHERIUM, EOBASILEUS, AND DIPLACODON ZONES.

(Figs. 1, 2, 8; Pl. I.)

HOMOTAXIS.

North America.—1, Lower 800 feet, *Uintatherium* zone, provisionally equivalent to upper part of the Bridger formation and equivalent beds in Washakie Basin. 2, Middle 350 feet, *Eobasileus* zone, equivalent to upper zone of Washakie Basin. 3, Upper 600 feet, *Diplacodon* zone, equals Uinta formation ("true Uinta"),[b] approaching if not equivalent to the lowermost levels of the White River Oligocene, i. e., lower *Titanotherium* zone or Chadron formation.

Europe.—Homotaxis is now very difficult owing to the absolute dissimilarity of the European and North American faunæ in these

[a] The name *Loxolophodon,* commonly applied by Cope and others to the Dinocerata of this stage, is preoccupied for a Wasatch coryphodont, *Loxolophodon semicinctus* Cope. *Tinoceras* Marsh is equally inapplicable because first applied to a Bridger uintathere.

[b] The Uinta formation as first noticed by Marsh (Introduction and succession of vertebrate life in America: Am. Jour. Sci., 3d ser., vol. 14, 1877, p. 337) included only the highest Eocene deposits, *Diplacodon* zone (horizon C, the "true or upper Uinta" of King and other writers), to which beds the name is here restricted.

stages; the climax of separation between the North American and western European faunæ is reached at this stage.

FAUNA.[a]

It is very important to note, as to the possible lower Oligocene age of the Uinta formation (*Diplacodon* zone): (1) That in the Bartonien of France, which is reckoned as upper Eocene, but not the highest stage, there appear the families Artiodactyla-Anthracotheriidæ and

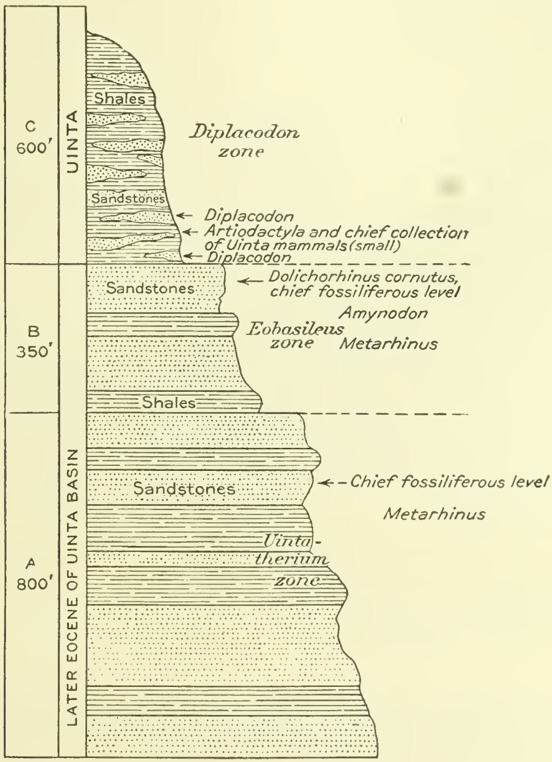


FIG. 8.—Columnar section of the Uinta formation, northern Utah. In A and B the diagram does not properly represent the irregular nature of the so-called sandstones and clays, which are probably in part coarser and finer volcanic-dust deposits. Modified from notes by O. A. Peterson, 1894. Faunistic studies of Osborn.

Perissodactyla-Chalicotheriidæ; (2) that in the Ludien, which is reckoned as uppermost Eocene, or the highest stage, there appear the families Marsupialia-Didelphyidæ and Rodentia-Sciuridæ; (3) that none of these four families are known to occur in deposits older than the lower Oligocene Plains formation of North America. We are therefore not justified, from our present knowledge, in transferring the Uinta formation (*Diplacodon* zone) to the lower Oligocene, as some authors (Scott) propose.

---

[a] See Appendix, p. 91.

Faunistic separation from western Europe in the upper Eocene.

Order.	Families peculiar to Europe.	Families common to western Europe and North America.	Families peculiar to North America.
Amblypoda			1
Insectivora	(?)	(?)	(?)
Creodonta		1	2
Primates	2	0	2
Rodentia	1		1
Carnivora	0	1	0
Artiodactyla	6	0	4
Perissodactyla	1	2	3
Cheiroptera	1	(?)	(?)
	11	4	13

Thus in the later Eocene of the Mountain Region (*Uintatherium*, *Eobasileus*, and *Diplacodon* zones) there are only 4 or 5 families in common with Europe out of a total of 28 to 30, whereas in the succeeding Oligocene Mountain and Plains regions (see p. 59) there are 21 families in common with Europe out of a total of 48.

The entire Uinta Basin deposition, as first fully explored by the American Museum expedition under Peterson,[a] overlaps in time both the upper Bridger and the entire "Washakie" deposition; thus it begins (Osborn) contemporaneously with the uppermost portion of the Bridger, is equivalent to the entire "Washakie," and then continues after the close of the "Washakie" into the Uinta (*Diplacodon* zone, "true or upper Uinta").[b] Its sparsely known mammalian fauna [c] is as follows:

Summary of genera.

Archaic Cretaceous mammals	6
Modern or Tertiary mammals	27
	33

The term Uinta formation (Marsh and King) is confined to the upper beds, or *Diplacodon* zone ("true Uinta").

PROVISIONAL FAUNAL LEVELS.

C. Uinta formation, 600 feet. *Diplacodon* zone. Distinguished by absence of Dinocerata; presence of Canidæ.

B. Middle beds of Uinta Basin, later Eocene, 350 feet. *Eobasileus* zone. Contains among Amblypoda-Dinocerata, *Eobasileus* (generic

[a] Osborn, H. F., Fossil mammals of the Uinta Basin, etc.: Bull. Am. Mus. Nat. Hist., vol. 7, 1895, pp. 71-105.

[b] This "true Uinta" fauna was that which was first determined and described by Marsh in 1870. The underlying *Uintatherium* and *Eobasileus* faunæ were first discovered by Peterson in 1894 and described by the writer.

[c] Scott, W. B., and Osborn, H. F., The Mammalia of the Uinta formation: Trans. Am. Philos. Soc., n. s., vol. 16, 1889, pp. 461-572.

reference uncertain); among Perissodactyla-Titanotheriidæ, *Dolichorhinus cornutus*. Creodonta-Mesonychidæ (last appearance). Closely equivalent to upper part of "Washakie" (B).

A. Lower beds of Uinta Basin, later Eocene, 800 feet, brown beds. ?*Uintatherium* zone, approximately equivalent to upper part of the Bridger (C–D) and to corresponding beds in Washakie Basin (A).

Of archaic mammals the Carnivora-Creodonta include 2 families, Mesonychidæ (last appearance) and Oxyænidæ (last appearance); the Hyænodontidæ, if existent, have not been discovered. The *Eobasileus* zone contains the last of the Amblypoda-Uintatheriidæ. Of modern mammals (Uinta) the Primates are little known as yet. Among Rodentia 2 families, (*a*) Ischyromyidæ (*Paramys*, *Pseudotomus*), (*b*) Heteromyidæ (*Protoptychus*). Among Pro-Carnivora, Miacidæ, also true Carnivora[a] (*Cynodictis*). Of Ungulata-Perissodactyla, 6 families: (*a*) Titanotheriidæ, horned animals of much greater size, especially increasing after the extinction of the huge Dinocerata, (*b*) Equidæ, (*c*) Lophiodontidæ (still to be discovered), (*d*) Tapiridæ, (*e*) Hyracodontidæ, (*f*) Amynodontidæ. No true Rhinocerotidæ. Ungulata-Artiodactyla now assume the five divisions or families which are found in the American Oligocene, namely: (*a*) Elotheriidæ-Achænodontinæ, mammals of large size; (*b*) Homacodontidæ (Dichobunidæ ?); (*c*) Oreodontidæ, North America only; (*d*) Hypertragulidæ, North America only; (*e*) Camelidæ, the first definite recognition of this family, North America exclusively until the Pliocene. The Uinta selenodonts[b] are all brachyodont and much alike in dentition; they are much less abundant than in the lower Oligocene.

OLIGOCENE.

IV. FOURTH FAUNAL PHASE.

Second modernization—First knowledge of the Great Plains fauna—Absence of all archaic mammals except Hyænodontidæ—Reestablishment of faunal resemblance with western Europe, followed by a long period of independent evolution and partial extinction of the same fauna to the close of the lower Miocene.

Environment; dry-land conditions in the Great Plains.—In addition to the geologic and faunistic evidence above cited we find collateral evidence from herpetology. The Testudinata, as analyzed by Dr. O. P. Hay,[c] furnish important proofs of prevailing dry-land conditions

[a] A rather arbitrary distinction, founded on the union of the scapholunar bones, which first occurs in certain Bridger species of the Miacidæ; the union is exceptional in the Bridger, presumably common in the Uinta, and universal in the White River. More essential distinctions are the small size of the brain and the absence of tympanic bullæ.

[b] Scott, W. B., The selenodont artiodactyls of the Uinta Eocene: Trans. Wagner Free Inst. Sci., Philadelphia, vol. 6, 1899, pp. ix–xiii, 1–121.

[c] In his monograph on the fossil turtles of North America, published by the Carnegie Institution.

in the Great Plains. How long previously these conditions had set in it is impossible to say. In the entire Oligocene and Miocene beds thus far only 6 species of water-living turtles have been described or recorded, and these are probably from river-channel sandstones, as compared with a very much larger number of land-living tortoises.

The details are as follows: (1) In the White River group (lower Oligocene) there occur 8 species of the Testudinidæ, including one of the land tortoise *Stylemys*; one species of *Testudo*, *T. brontops* Marsh, belongs to the Chadron formation, or *Titanotherium* zone; all of these are land tortoises, mostly found in Colorado. Of water-living forms the White River group of South Dakota has furnished one species of the Emydidæ, river turtles, and one of the Dermatemydidæ, a small family related to the Chelydridæ and now confined to Central America. (2) In the middle part of the John Day formation (upper Oligocene, Mountain Region) there are 3 species of *Stylemys*, land tortoises. (3) In the Deep River sequence (middle Miocene, Mountain Region) occurs a single species of *Testudo*; from the Mascall formation of Oregon there is known a species of *Clemmys*, a genus now living in America and Asia. From the deposits on Pawnee Creek, Colorado, come 2 large species of *Testudo*. (4) The "Loup Fork beds" (upper Miocene, Plains Region) furnish 7 species of *Testudo*, approaching in size the great tortoises of the Galapagos Islands. (5) From the Rattlesnake formation of Oregon (Pliocene) occurs a species of *Clemmys*, a land tortoise.

Modernization in North America.—A second American modernization, as remarkable as the first or Wasatch modernization, is shown by the first appearance of 16 families of mammals which have not as yet been certainly recognized in the Mountain Eocene basins, namely, 6 existing families of Rodentia, 4 existing families of Carnivora, 4 existing families of Insectivora, 1 existing family of Perissodactyla, 1 now extinct European family of Artiodactyla.

Modernization in Europe.—A very similar modernization occurred in western Europe.[a] In the Ludien (= lower Oligocene, Lapparent, uppermost Eocene, Depéret), Sannoisien, and Stampien (= lower Oligocene) 17 modern or still existing families which have not been found in earlier geologic stages appear for the first time. Of these new families, 6 appeared simultaneously in North America.

[a] This generalization is chiefly based upon the faunal lists of Depéret (see footnote, p. 9).

Faunistic reunion with western Europe in the Oligocene.

Order.	Western European families not found in North American Oligocene.	Families common to western Europe and North America by contemporaneous or previous migration.	North American families not found in western European Oligocene.
Edentata	1	0	0
Rodentia	5	4	3
Insectivora	1	3	2
Creodonta	0	1	0
Marsupialia	0	1	0
Carnivora	[a] 3	3	1
Artiodactyla	5	2	4
Perissodactyla	1	[b] 7	1
	16	21	11

[a] Subfamily.
[b] The Titanotheriidæ found in central Europe are included in this number. Dr. H. G. Stehlin (letter, April 15, 1907?) regards the geologic level of these animals as Oligocene. They closely resemble certain of our titanotheres.

Thus (1) the faunal community with western Europe becomes much closer than in the upper Eocene (see p. 56); (2) it is important to note that many American lower Oligocene types are represented by more primitive forms of European upper Eocene types and partly of north African types, namely, *Hyænodon*, *Hyopotamus*, *Elotherium*, and Suoidea-Dicotylidæ; (3) the strongest community is among the Perissodactyla, with 7 families out of 9 in common; (4) the least community is among the Artiodactyla, with only 2 families out of 11 in common.

As above noted, this momentous faunal change in North America may be more apparent than real, because attributable to various causes: (1) Partly to the fact that this is our first glimpse of the western portion of the Great Plains fauna; (2) partly to fresh migration from the northerly or North American-Eurasiatic region. The apparent sharp distinctions of this phase from the Uinta faunal phase will probably be partly lessened when a fuller knowledge of the Uinta mammals shall have been gained.

There are many distinctive characters of this North American faunistic stage, as follows: (1) First appearance of Marsupialia-Didelphyidæ and of Rhinocerotidæ-Diceratheriinæ; (2) sudden disappearance of all Primates, which do not again appear in North America; (3) continued evolution of certain of the North American families of mammals derived from the first modernization, 4-toed horses replaced by 3-toed horses, advanced evolution of American Eocene Rodentia (*Paramys*, *Sciuravus*), appearance of Eurasiatic Rodentia; (4) extinction of other modernized North American families, including especially 4 families of Perissodactyla, also, Insectivora-Hyopsodontidæ; (5) migration, probably from Eurasia, of some new

families—Perissodactyla-Chalicotheriidæ, Artiodactyla-Anthracotheriidæ, Suoidea, Creodonta-Hyænodontidæ; (6) first appearance of Carnivora-Mustelidæ, probably from the northern continental mass, also Canidæ and Felidæ-Machærodontinæ; (7) probable migration to Eurasia of some of the North American families, Perissodactyla-Tapiridæ, Amynodontidæ.

LOWER OLIGOCENE, WHITE RIVER GROUP OF HAYDEN (EUROPE, ÉTAGE SANNOISIEN [TONGRIEN INFÉRIEUR]).

7. CHADRON FORMATION; TITANOTHERIUM ZONE.

(Figs. 1, 9, 10; Pls. I–III.)

HOMOTAXIS AND SYNONYMY.

North America.—1, Horizon A of Hayden and Leidy; lower part of the White River group; 2, Chadron formation, 200 feet, of Darton; 3, "*Titanotherium* beds" [a] of Leidy and Hayden, South Dakota; 4, "Horsetail Creek beds" of Matthew,[b] northeastern Colorado and western Nebraska; 5, Monument Creek formation (upper part) of Darton; 6, White River deposits along Pipestone Creek, Montana (Douglass, 1902); and 7, White River deposits along Swift Current Creek, Cypress Hills, British Columbia,[c] etc.

Europe, provisional homotaxis.—Ludien, in part; Sannoisien (Tongrien inférieur); Stampien (Tongrien supérieur).

FAUNA.[d]

It is important to note again that four or more of the newly appearing families of mammals are represented in the upper Eocene of Europe. Our knowledge of the animals of this stage, which is at present considered lower Oligocene, is still rather limited except as to the Titanotheriidæ, which are very abundant and characteristic. In the White River beds at Pipestone Springs, Montana,[e] were first discovered (Douglass[f]) the animals of smaller size or microfauna. In all the other deposits chiefly the larger animals are known.

[a] Hatcher, J. B., The *Titanotherium* beds: Am. Naturalist, Mar. 1, 1893, pp. 204–221.

[b] Matthew, W. D., Stratigraphy of the White River and Loup Fork formations: Bull. Am. Mus. Nat. Hist., vol. 1, pt. 7, 1901, pp. 355–374.

[c] Cope, E. D., The White River beds of Swift Current River, Northwest Territory (Geol. Oligocene White River): Am. Naturalist, Feb., 1885. Also Ann. Rept. Geol. and Nat. Hist. Survey Canada, vol. 1, 1885 (1886), appendix to Article C, pp. 79–85.

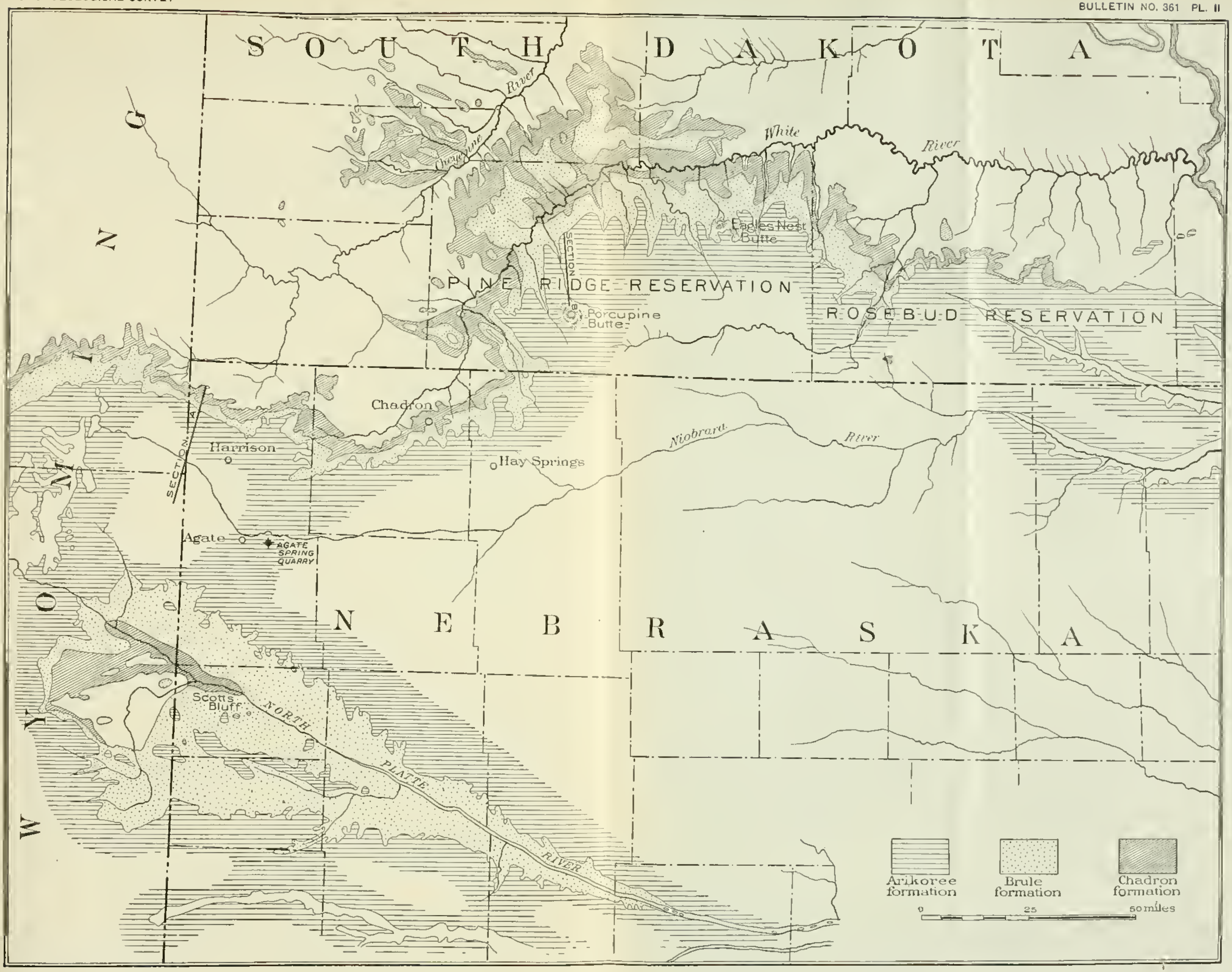
[d] See Appendix, p. 91.

Scott, W. B., and Osborn, H. F., Preliminary account of the fossil mammals from the White River formation contained in the Museum of Comparative Zoology: Bull. Mus. Comp. Zool. Harvard Coll., vol. 13, 1887, pp. 151–171.

Osborn, H. F., and Wortman, J. L., Fossil mammals of the lower Miocene White River beds, coll. 1892: Bull. Am. Mus. Nat. Hist., vol. 6, 1894, pp. 199–228.

[e] Matthew, W. D., The fauna of the *Titanotherium* beds of Pipestone Springs, Montana: Bull. Am. Mus. Nat. Hist., vol. 19, 1903, pp. 197–226.

[f] Douglass, Earl, New vertebrates from the Montana Tertiary: Ann. Carnegie Mus., vol. 2, No. 2, 1903, pp. 145–200. (White River stratigraphy.)



OLIGOCENE (CHADRON, BRULE) AND MIOCENE (ARIKAREE, HARRISON, ROSEBUD) EXPOSURES IN SOUTH DAKOTA, NORTHWESTERN NEBRASKA, AND EASTERN WYOMING.

After Darton's survey, 1905, modified by observations of Matthew and Thomson (1906–7). For section A see fig. 14; for section B see fig. 12.

The archaic mammals are now represented only by the true Hyænodontinæ, which are probably of European and African origin. Among Marsupialia, Didelphyidæ are somewhat doubfully recorded in this stage.

Of the modernized mammals, among Rodentia (*a*) Ischyromyidæ, represented by *Ischyromys*; *Paramys* disappears or gives rise to *Sciurus*; and there first appear the modern (*b*) Leporidæ, (*c*) Castoridæ, (*d*) Sciuridæ, and (*e*) Geomyidæ. Of Insectivora the Leptictidæ continue, as well as animals analogous in dentition to *Centetes* and *Solenodon*. The Carnivora are thoroughly modernized by the appearance of true Canidæ (*Cynodictis*, *Daphænus*), Mustelidæ, and Felidæ (Machærodontinæ). Eight families are known of Ungulata-Perissodactyla, including 6 Eocene families which survive from the upper Eocene, namely, (*a*) Equidæ, (*b*) Tapiridæ, (*c*) Amynodontidæ, (*d*) Hyracodontidæ, (*e*) Lophiodontidæ, (*f*) Titanotheriidæ,[a] which reach the climax of their evolution and suddenly disappear, (*g*) the aberrant Perissodactyla-Chalicotheriidæ are first positively recognized, (*h*) the Rhinocerotidæ, ancestors of *Diceratherium*, and another subfamily (?Aceratheriinæ) also first appear. Of Artiodactyla 6 families occur, as follows: Three previously known Eocene families, (*a*) Oreodontidæ, (*b*) Camelidæ, and (*c*) Hypertragulidæ, continue; (*d*) the Dicotylidæ first appear, either of American origin from the Great Plains or of Eurasiatic origin as a side branch of the Suoidea; (*e*) the Anthracotheriidæ also first appear, probably by migration from Europe, and are represented by *Hyopotamus* in the Chadron formation; (*f*) the bunodont Achænodontinæ of the upper zones in the Washakie and Uinta basins are succeeded or replaced by the Elotheriinæ or Entelodontinæ closely allied to the European *Entelodon*.

Monument Creek formation.—The following description of this formation is taken from a paper by Darton published in 1906:[b]

On the high divide between the Platte and Arkansas drainage basins, at the foot of the Rocky Mountains, there is an extensive deposit of conglomerates, sand, sandstone, gravel, and clay, known as the Monument Creek formation. It lies on the Laramie formation to the east and the Arapahoe formation to the west, and at Palmer Lake it abuts against the granite at the foot of the mountain. There are two members, a lower one of sands and clays and an upper one of conglomerate and sandstone. The latter caps numerous buttes and plateaus in the high region west and north of Calhan and north of Monument.

Fossil bones of *Titanotherium* have been discovered by the writer[c] and Mr. C. A. Fisher in the upper member in the region north of Calhan and southwest of Elizabeth, which indicate that this portion of the formation is of Oligocene age. The lower member may be Oligocene, or perhaps Wasatch or Bridger, in age.

---

[a] Osborn, H. F., The four phyla of Oligocene titanotheres: Bull. Am. Mus. Nat. Hist., vol. 16, 1902, pp. 91-109.

[b] Darton, N. H., Geology and underground waters of the Arkansas Valley in eastern Colorado: Prof. Paper U. S. Geol. Survey No. 52, 1906.

[c] Darton, N. H., Age of Monument Creek formation: Am. Jour. Sci., 4th ser. vol. 20, 1905, pp. 178-180.

MIDDLE OLIGOCENE (EUROPE, ÉTAGE STAMPIEN [TONGRIEN SUPÉRIEUR]).

9. LOWER PART OF BRULE CLAY (DARTON); OREODON ZONE AND "METAMYNODON SANDSTONES."

(Figs. 1, 9, 10; Pls. I-III.)

HOMOTAXIS AND SYNONYMY.

North America.—1, Horizons B and C of Hayden and Leidy. 2, *Oreodon* zone of Leidy. 3, Lower Brule clay of Darton.[a] 4, "*Metamynodon* sandstones" of Wortman.[b] (1–4 all of South Dakota.) 5, "Cedar Creek beds" of Matthew,[c] northeastern Colorado. 6, Widespread similar exposures in southeastern Wyoming, South Dakota, and northwestern Nebraska. 7, Scattered exposures in western Montana.

Europe.—Approximate homotaxis with the Stampien or Oligocène moyen of Europe is indicated by similar stages in the evolution of Artiodactyla-Anthracotheriidæ (*Hyopotamus*), of Perissodactyla-Amynodontidæ (e. g., *Metamynodon*, *Cadurcotherium*), of Tapiridæ, of Rhinocerotidæ, and of Chalicotheriidæ. Also by the apparent disappearance in both countries of Perissodactyla-Amynodontidæ and Creodonta-Hyænodontidæ in the upper *Oreodon* zone.

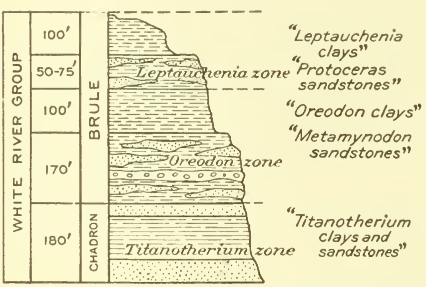


Fig. 9.—Diagrammatic section of the White River group, South Dakota. (Cf. Pl. II.) Chiefly after Wortman, 1892.

FAUNA.[d]

The rich mammalian fauna (more than 48 species being known in the big badlands of South Dakota alone) is distinguished negatively by the absence of *Titanotherium* and positively by the presence of abundant oreodonts.

The important distinction was first made by Matthew[e] that the Brule clay, or *Oreodon* zone, of fine, still-water or eolian composition,

---

[a] Darton, N. H., Preliminary report on the geology and underground-water resources of the central Great Plains: Prof. Paper U. S. Geol. Survey No. 32, 1905.

[b] Wortman, J. L., On the divisions of the White River or lower Miocene of Dakota: Bull. Am. Mus. Nat. Hist., vol. 5, 1893, pp. 95–105.

Osborn, H. F., and Wortman, J. L., Fossil mammals of the lower Miocene White River beds: Bull. Am. Mus. Nat. Hist., vol. 6, 1894, p. 200 (section).

[c] Matthew, W. D., Fossil mammals of the Tertiary of northeastern Colorado: Mem. Am. Mus. Nat. Hist., vol. 1, pt. 7, 1901, p. 357.

[d] See Appendix, p. 91.

[e] Is the White River Tertiary an eolian formation? Am. Naturalist, vol. 33, 1899, p. 404.

contains chiefly the Plains fauna, while the irregular "*Metamynodon* sandstones," traversing the lower *Oreodon* zone and of river-channel origin, contain chiefly the forest and aquatic fauna. (See fig. 9.) Forested, fluviatile, and plains or open-country conditions are indicated by the mingling of many mammals of modern type in the respective fluviatile and plains deposits.

Among Insectivora the first North American erinaceid (*Proterix*) appears. Rodentia include 16 genera; we note the last appearance of the Eocene Ischyromyidæ and the first appearance of the modern Muridæ. Of Carnivora-Canidæ, *Cynodictis* and *Daphænus* continue from the underlying *Titanotherium* zone; of Felidæ, 3 genera of Machærodontinæ; of Mustelidæ, *Bunælurus*. The Perissodactyla are reduced to 7 families: (*a*) Equidæ (species numerous and diversified); (*b*) Tapiridæ; (*c*) Lophiodontidæ (their last appearance); (*d*) Amynodontidæ (their last appearance); (*e*) Rhinocerotidæ (including 2 genera); (*f*) Hyracodontidæ. Artiodactyla include 8 families: (*a*) Leptochœridæ; (*b*) Elotheriidæ; (*c*) Dicotylidæ; (*d*) Agriochœridæ; (*e*) Oreodontidæ; (*f*) Camelidæ; (*g*) Anthracotheriidæ; (*h*) Hypertragulidæ.

UPPER OLIGOCENE, FIRST PHASE.

10. UPPER PART OF BRULE CLAY; LEPTAUCHENIA ZONE AND "PROTOCERAS SANDSTONES."

(Figs. 1, 9, 10; Pls. I-III.)

HOMOTAXIS.

North America.—1, Horizon C of the Hayden and Leidy section. 2, Upper part of White River formation of South Dakota. 3, Brule clay (upper part) of Darton,[a] 1897. *Leptauchenia* zone of Wortman. The "*Protoceras* sandstones" contain the forest and fluviatile fauna; the clays of the *Leptauchenia* zone contain the plains fauna. 4, Lower part of "Martin Canyon beds" of Matthew,[b] northeastern Colorado. 5, Deposits at White Buttes, North Dakota.

FAUNA.[c]

Characterized negatively, so far as we know, by disappearance or absence of the Hyænodontidæ, the last of the archaic Mammalia; by extinction or absence of the Eocene Rodentia-Ischyromyidæ; by extinction of 2 families of Perissodactyla, Lophiodontidæ and Amynodontidæ.

---

[a] Prof. Paper U. S. Geol. Survey No. 32, 1905.

[b] Fossil mammals of the Tertiary of northeastern Colorado: Mem. Am. Mus. Nat. Hist., vol. 1, pt. 7, 1901, pp. 353–447.

[c] See Appendix, p. 91.

Among Carnivora there now appear in North America representatives of all the existing families except (1) Viverridæ and Hyænidæ, which never reached America; (2) true Felinæ, which first appear in the middle Miocene; (3) Procyonidæ, which first appear in the lower Miocene; and (4) Ursidæ, which first appear in the middle Pleistocene of North America. Among Rodentia is noted the first appearance (lower part of the John Day of Oregon) of the distinctively American Haplodontidæ; also of the Castoridæ (*Steneofiber*). Among Insectivora, first appearance of the Talpidæ in North America (the Eocene forms with analogous teeth may be ancestral). Among surviving Perissodactyla is noted the presence of numerous larger members of the Equidæ, Tapiridæ, and Rhinocerotidæ, the latter family including (*a*) members of the Diceratheriinæ with very rudimentary horns, and (*b*) members of the Aceratheriinæ of larger size. Artiodactyla now become very distinctive: Among Oreodontidæ *Leptauchenia* and *Eporeodon* appear; among Anthracotheriidæ *Hyopotamus* continues; among Camelidæ *Protomeryx* replaces *Poëbrotherium;* among Hypertragulidæ *Protoceras* (first appearance of this type) is the most distinctive form in the sandstones of South Dakota.

While the "*Protoceras* sandstones" and the clays of the *Leptauchenia* zone were being deposited in the Plains Region, there began the volcanic-ash depositions of the John Day formation in the Mountain Region of Oregon.

OREGON CENOZOIC FORMATIONS.

RÉSUMÉ OF THE OREGON DEPOSITS AS A WHOLE.

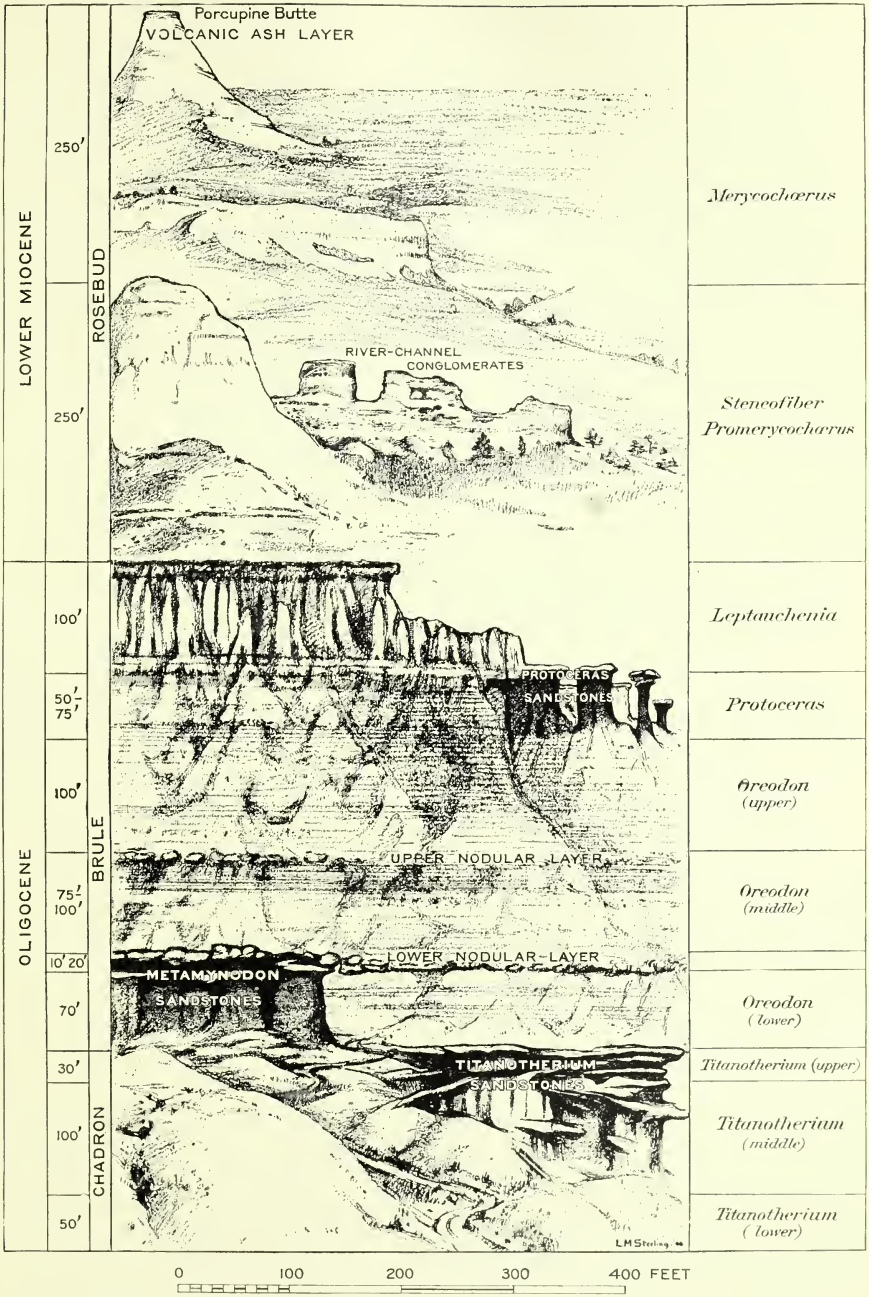
The known mammal fauna of Oregon, as determined partly by Cope and Wortman and more precisely as to levels by Merriam and Sinclair, is found on five levels, partly separated by volcanic overflows, as follows:

Rattlesnake	= upper Miocene	= *Procamelus* zone.
Mascall	= middle Miocene	= *Merychippus* zone.
Upper part of John Day	= Transition, upper Oligocene, lower Miocene	= *Promerycochœrus* zone.
Middle (fossils numerous) and (?) lower parts of John Day	= upper Oligocene, second phase	= *Diceratherium* zone

JOHN DAY FORMATION.

(Figs. 1, 10, 11; Pl. I.)

Age.—The time of the beginning of the John Day deposition appears to correspond with that of the close of the *Leptauchenia* zone in the South Dakota region (fig. 10), namely, the upper Oligocene.



IDEALIZED BIRD'S-EYE VIEW OF THE GREAT BADLANDS OF SOUTH DAKOTA, SHOWING CHANNEL AND OVERFLOW DEPOSITS IN THE OLIGOCENE AND LOWER MIOCENE.

Looking southeast across Cheyenne and White rivers to Porcupine Butte, on Porcupine Creek, Pine Ridge Reservation. The location of the panorama is shown in Pl. II, approximately on the line of section B. The ancient river-channel deposits in the successive levels are the "*Titanotherium* sandstones," "*Metamynodon* sandstones," and "*Protoceras* sandstones." River-channel conglomerates appear in the Rosebud levels also.

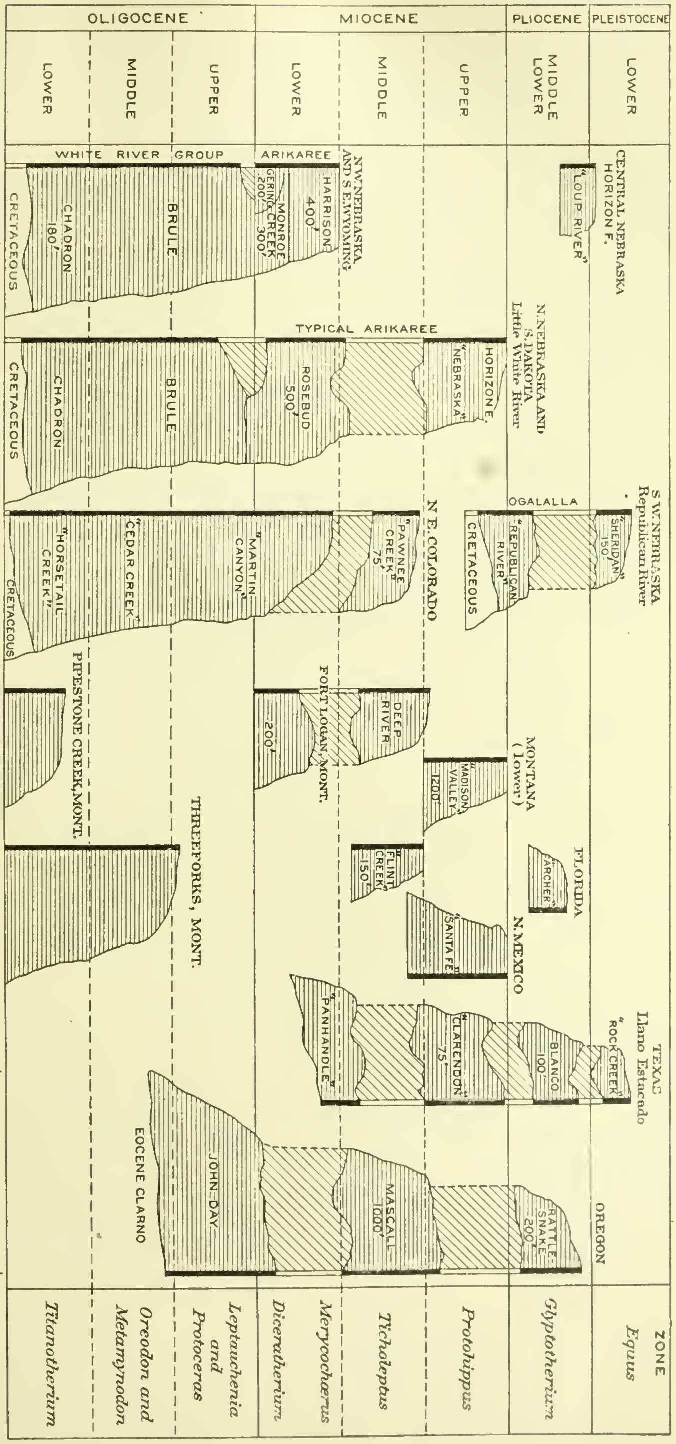


Fig. 10.—Provisional correlation of some of the chief epicontinental Oligocene-Pleistocene deposits and formations of the West in which fossil mammals have been recorded. Unlike the sections in the other figures, these sections are not represented to scale; they are purely conventional. After W. D. Matthew and H. F. Osborn. 1907.

Conditions of deposition.—The volcanic materials of the John Day were chiefly wind blown, as described by Merriam;[a] there is little evidence of fluviatile conditions. The Mollusca are terrestrial or air breathing, with the exception of one locality which contains fluviatile Mollusca. The Testudinata, genus *Stylemys*, are of the *Testudo*, or terrestrial type; no fluviatile types have been recorded. The so-called beavers (Castoridæ) are not the true river-living beavers (Peterson).

Fauna.[b]—The known fauna of the John Day formation as a whole is chiefly of open-forest and savanna-living type. We note the entire disappearance of the ancient fauna, Creodonta-Hyænodontidæ, and do not observe the introduction or invasion from Eurasia of any new families of mammals. The major part of the John Day fauna is of upper Oligocene age, but in its latest phases it is perhaps transitional to lower Miocene. The fauna is thus broadly transitional between that of the White River group and the Arikaree formation.

The more ancient Ischyromyidæ having disappeared, the modern Rodentia are represented by 6 existing families—Sciuridæ, Castoridæ, Geomyidæ, Muridæ, Leporidæ, and Haplodontidæ (*Allomys*, *Mylagaulodon*). Among the Carnivora highly varied Canidæ abound, the Felidæ are numerous but confined to the machærodont type, and there is a single member of the Mustelidæ, *Oligobunis*. The Perissodactyla begin to be reduced to the 3 existing families of Equidæ, Tapiridæ, and Rhinocerotidæ; the aberrant Chalicotheriidæ occur. Among Artiodactyla, the Elotheriidæ attain a great size; in the middle part of the John Day the peccary-like pigs, Dicotylidæ, are found in great numbers; a wider differentiation arises among the Oreodontidæ, but *Leptauchenia* does not occur here. In the upper part of the John Day the members of the Camelidæ are first recorded (Sinclair) and begin to attain considerable size; a species of *Paratylopus* or *Miolabis* occurs, resembling the species of the lower Arikaree. The lower John Day fauna is so little known that no deductions can be made from it, except that it appears to be closely related to that of the middle John Day.

The faunistic comparison of the John Day formation therefore begins with the middle John Day, which is highly fossiliferous and slightly more advanced than that of the upper portion of the Brule clay and "*Protoceras* sandstones," as will now be shown.

---

[a] A contribution to the geology of the John Day basin; Bull. Univ. California, Dept. Geology, vol. 2, 1901, pp. 269-314.

[b] See Appendix, p. 91.

UPPER OLIGOCENE, SECOND PHASE (EUROPE, ÉTAGE AQUITANIEN).

11. MIDDLE PART OF JOHN DAY FORMATION; DICERATHERIUM ZONE (ALSO UPPER PART OF JOHN DAY, TRANSITIONAL).

(Figs. 1, 10, 11; Pl. I).

HOMOTAXIS AND SYNONYMY.

America.—1, Middle part of the John Day formation of Oregon.[a] 2, *Diceratherium* zone of Wortman (500 to 1,000 feet).

Europe.—Aquitanien. Homotaxis with the Aquitanien of France (typified by the St. Gérand-le-Puy, Allier) is close, as indicated by

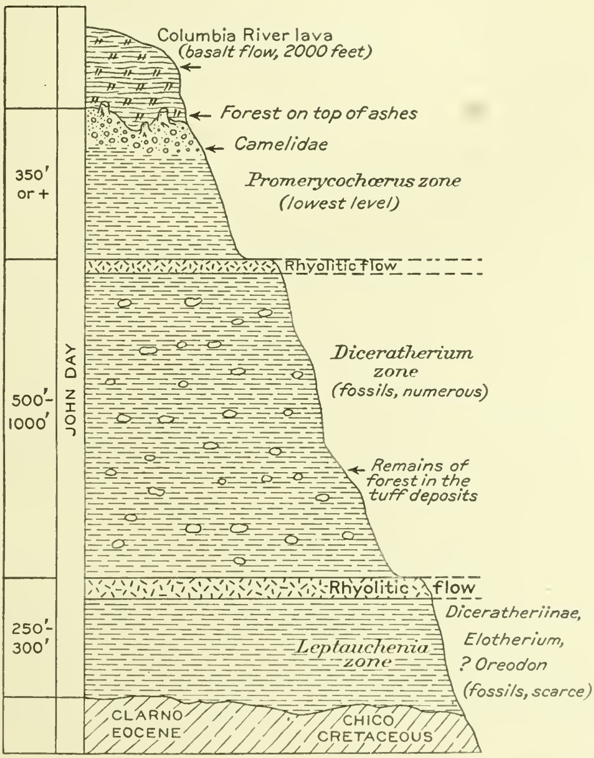


FIG. 11.—Columnar section of the John Day formation (Oregon), based on studies by Merriam and Sinclair.

similar stages in the evolution of Perissodactyla-Tapiridæ, Diceratheriinæ, Aceratheriinæ, Chalicotheriidæ, and other families.

FAUNA.[b]

The evolution stages in members of this typical Mountain fauna of the middle part of the John Day are in some families (e. g., Equidæ,

[a] Merriam, J. C., op. cit.

[b] Full John Day lists were kindly prepared for this paper by Dr. William J. Sinclair from Professor Merriam's and his own personal notes. (See also Appendix, p. 91.)

Tapiridæ) similar to those of the Brule clay, in others (e. g., Rhinocerotoidea, Rodentia) more advanced than those of the upper Brule clay and "*Protoceras* sandstones." This more or less progressive character is illustrated as follows: Among Perissodactyla-Rhinocerotidæ *Diceratherium* is more advanced, with well-developed horn cores; among Tapiridæ *Protapirus* is similar to that in the "*Protoceras* sandstones;" among Equidæ browsing horses, small and similar to those of the "*Protoceras* sandstones." Among Artiodactyla 5 families: Elotheriidæ, Hypertragulidæ, Oreodontidæ (*Eporeodon, Agriochœrus*), Dicotylidæ, Camelidæ (not certainly present). Among Carnivora-Felidæ (*Archælurus, Nimravus*); among Canidæ *Nothocyon, Temnocyon, Mesocyon, Philotrox.* Among Rodentia Leporidæ (*Lepus*), Castoridæ (*Steneofiber*); also two new and peculiarly American rodent families, Geomyidæ (pocket gophers) and Haplodontidæ (sewellels, *Meniscomys*).

The conclusion is that the middle John Day deposition partly overlaps and is partly sequent to the deposition of the upper part of the Brule clay and the "*Protoceras* sandstones."

UPPER OLIGOCENE, LATEST PHASE (EUROPE, ÉTAGE AQUITANIEN).

12. UPPER PART OF JOHN DAY FORMATION; PROMERYCOCHŒRUS ZONE.

(Figs. 1, 10, 11; Pl. I.)

HOMOTAXIS.

North America (provisional).—Great Plains: 1, Lower portion of Rosebud, of Matthew. 2, Gering, of Peterson's Running Water section. (See fig. 13.) 3, ? Gering, of Darton's Scotts Bluff section.

FAUNA,[a] EARLY PHASE.

The fauna of the upper part of the John Day formation is rich, but the levels have been certainly recorded only in the case of the following animals: Among Rodentia, *Lepus, Entoptychus, Mylagaulodon.* Among Carnivora-Canidæ, *Nothocyon, Mesocyon, Temnocyon.* Among Perissodactyla, (*a*) Equidæ, *Anchitherium præstans, Mesohippus acutidens;* (*b*) Tapiridæ, *Protapirus;* (*c*) Rhinocerotidæ, ? Diceratheriinæ, ? Aceratheriinæ. Among Artiodactyla, (*a*) Elotheriidæ, (*b*) Dicotylidæ, (*c*) Oreodontidæ, *Promerycochœrus*, 4 species, *Eporeodon,* (*d*) Hypertragulidæ, (*e*) Camelidæ, *Paratylopus sternbergi, P. cameloides.*[b]

TRANSITION FROM UPPER OLIGOCENE TO LOWER MIOCENE IN UPPER PARTS OF JOHN DAY, GERING, AND HARRISON AND LOWERMOST PART OF ROSEBUD.

From the preceding American Oligocene (upper part of Brule clay or *Leptauchenia* zone, and lower and middle parts of the John Day)

---

[a] See Appendix, p. 91.

[b] The only camels from the John Day obtained by the University of California expeditions came from the top of the formation. The matrix of the type of *P. sternbergi* shows that it is not from the middle John Day, as Wortman supposed (Sinclair, November, 1906).

the transition beds are sharply demarcated positively (1) by the sudden appearance among Artiodactyla-Oreodontidæ of *Promerycochœrus* followed in higher levels by *Merycochœrus* and *Merychyus;* (2) by the survival of progressive species of *Leptauchenia* in the same family; (3) among Artiodactyla also, 3 families of earlier horizons apparently have become extinct, namely, Anthracotheriidæ (which also disappear in the Aquitanien of France), Leptochœridæ, and Oreodontidæ-Agriochœrinæ.

COMPARISON WITH EUROPEAN HORIZONS OF UPPER OLIGOCENE AGE.

The upper part of the John Day formation, or *Promerycochœrus* zone, of the Mountain region of Oregon, as well as the Gering and Monroe Creek formations of Hatcher, the Gering or lower Arikaree of Darton, the Rosebud (lower levels, see fig. 12) of Matthew, all in the Plains region of South Dakota, may be regarded as covering the transition between the Oligocene and Miocene epochs, as these divisions are employed in France. They resemble chiefly the upper Oligocene of France. (1) The upper part of the John Day of the Mountain region is somewhat older than the lower part of the Rosebud of the Plains, although both contain *Promerycochœrus.* (2) Recent explorations in the upper portion of the Harrison and equivalent formations [a] reveal a fauna which partly resembles that of the upper Oligocene of France (an Oligocene character is given by the survival of *Elotherium*); at the same time, it contains a primitive *Amphicyon*, a characteristic Miocene form. The newer fauna of these beds is slightly subsequent to that of St. Gérand-le-Puy (generally regarded as upper Oligocene or Aquitanien, although several authorities place it in the lower Miocene). (3) The resemblance to the Aquitanien consists in the presence of Rhinocerotoidea-Diceratheriinæ, in the nonappearance of *Mastodon* among Proboscidea, and in the nonappearance of *Teleoceras* among Rhinocerotoidea. (4) It differs from the Aquitanien proper in the survival of Artiodactyla-Elotheriidæ, which disappear in the middle Oligocene of France. (5) It contains Chalicotheriidæ apparently near *Macrotherium,* a Miocene stage. (6) From a recent comparison of these fauna, Matthew writes (March, 1907):

> The above comparisons indicate that the Rosebud faunæ are later than the upper Oligocene and earlier than the middle Miocene of the European standard. Their position is thereby fixed as lower Miocene, representing an earlier and a later stage.

It is concluded that the upper part of the John Day, for the present, may be somewhat arbitrarily separated as the American upper Oligocene, while the partly contemporaneous and partly sequent Plains formations may be termed lower Miocene.

---

[a] Matthew, W. D., A lower Miocene fauna from South Dakota: Bull. Am. Mus. Nat. Hist., vol. 23, 1907, pp. 169-219.

"From these discoveries it appears that the Miocene section from the Oligocene to the top of the Nebraska beds, in this general locality, may perhaps have to be regarded as lower Miocene."—Peterson, O. A., The Agate Spring fossil quarry: Ann. Carnegie Mus., vol. 3, No. 4, 1906, p. 491.

MIOCENE.

IV. FOURTH FAUNAL PHASE—Continued.

LOWER MIOCENE (EUROPE, ÉTAGES AQUITANIEN, BURDIGALIEN).

13. ARIKAREE FORMATION, PROMERYCOCHŒRUS ZONE (GERING, MONROE CREEK, HARRISON, AND ROSEBUD OF DARTON, HATCHER, AND MATTHEW).

(Figs. 1, 10, 12–14; Pl. I.)

GENERAL FEATURES.

Geology and nomenclature.—This Great Plains formation, officially designated Arikaree by the Survey was recognized as horizon D by Hayden, and, as shown in the synonymy below (p. 71), has been variously divided and named by Darton, Hatcher, and Matthew. It is

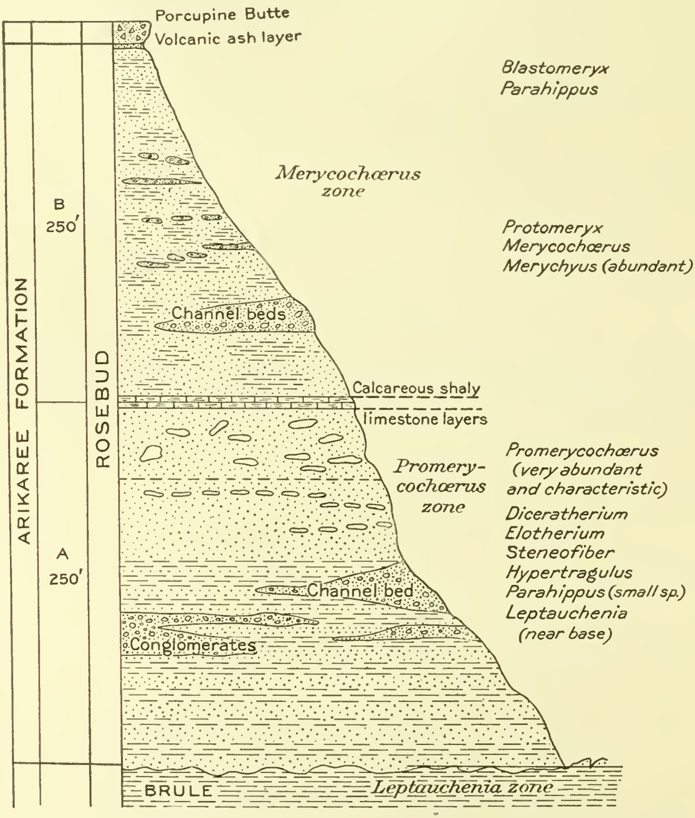


FIG. 12.—Columnar section of the Rosebud formation, after observations by Matthew and Thomson, 1906. For the chief line of this section see section B, Pl. II.

extensively exposed along the Pine Ridge Bluffs of South Dakota on the south side of White River and along Niobrara River, as mapped by Darton.[a] (See Pl. I.) It extends more than 100 miles east and

[a] Preliminary report on the geology and water resources of the central Great Plains: Prof. Paper U. S. Geol. Survey No. 32, 1905, pl. 35.

west. It immediately overlies throughout, conformably or unconformably, the upper part of the Brule clay or *Leptauchenia* zone. In some places lithologically, and everywhere faunistically, it can be divided into lower and upper levels.

Synonymy.—The typical Gering formation of Darton, 1899, is at Scotts Bluff, western Nebraska; the broad extension by Darton of this formation to other localities is somewhat doubtful. The name Gering formation as used by Darton, Hatcher, and Peterson probably applies to noncontinuous river sandstones and conglomerates (maximum 200 feet), which are in a manner analogous to the "*Titanotherium*," "*Metamynodon*," and "*Protoceras* sandstones" that traverse the lower Arikaree clays or finer beds and partly erode irregular channels in the upper Brule clay (*Leptauchenia* zone). This formation is thus probably of the same age as the lower parts of the Arikaree, Monroe Creek, and Rosebud. Its known fauna is very limited. The so-called Gering of Hatcher and Peterson is in southeastern Wyoming and northwestern Nebraska; in their section it is said to be lithologically similar to the overlying Monroe Creek.

The typical Arikaree formation of Darton, 1899, is at Pine Ridge Bluffs, in South Dakota; whether or not this extends to southeastern Wyoming rests on future paleontological correlation. The Arikaree as described and mapped by Darton would broadly include the whole of the Rosebud formation of Matthew, as well as the Monroe Creek and Harrison, and broadly cover the whole of the Miocene. The entire Arikaree formation of Darton consists of finer materials, whitish or light-buff sandstones, more continuous and widespread, lying either on the Gering formation or on the Brule clay.

There remain to be compared, therefore, the faunæ contained in two sections about 95 miles apart east and west, probably continuous, substantially similar lithologically, and containing a substantially similar fauna. This comparison is based on the valuable recent papers of Peterson and Matthew (cit. supra). The local names Monroe Creek, Harrison, and Rosebud may all be retained until the question of geologic identity or dissimilarity can be settled.

Approximate correlations of the Arikaree formation.

	Westerly section: Southeastern Wyoming and northwestern Nebraska. Hatcher, 1902; Peterson, 1906. (See fig. 13.)		Easterly section: South Dakota, Porcupine Creek. Matthew, Gidley, 1904; Matthew, Thomson, 1906. (See fig. 12.)	
		Feet.		*Feet.*
Upper division	Upper part of Harrison	200	Upper part of Rosebud	[a]250
Lower division	Lower part of Harrison	200	Lower part of Rosebud	[a]250
	Upper part of Monroe Creek	300		
	Lower part of Monroe Creek (Gering of Hatcher and Peterson).	200		
	Upper part of Brule clay, or *Leptauchenia* zone.	150	Upper part of Brule clay, or *Leptauchenia* zone.	....

[a] Estimated.

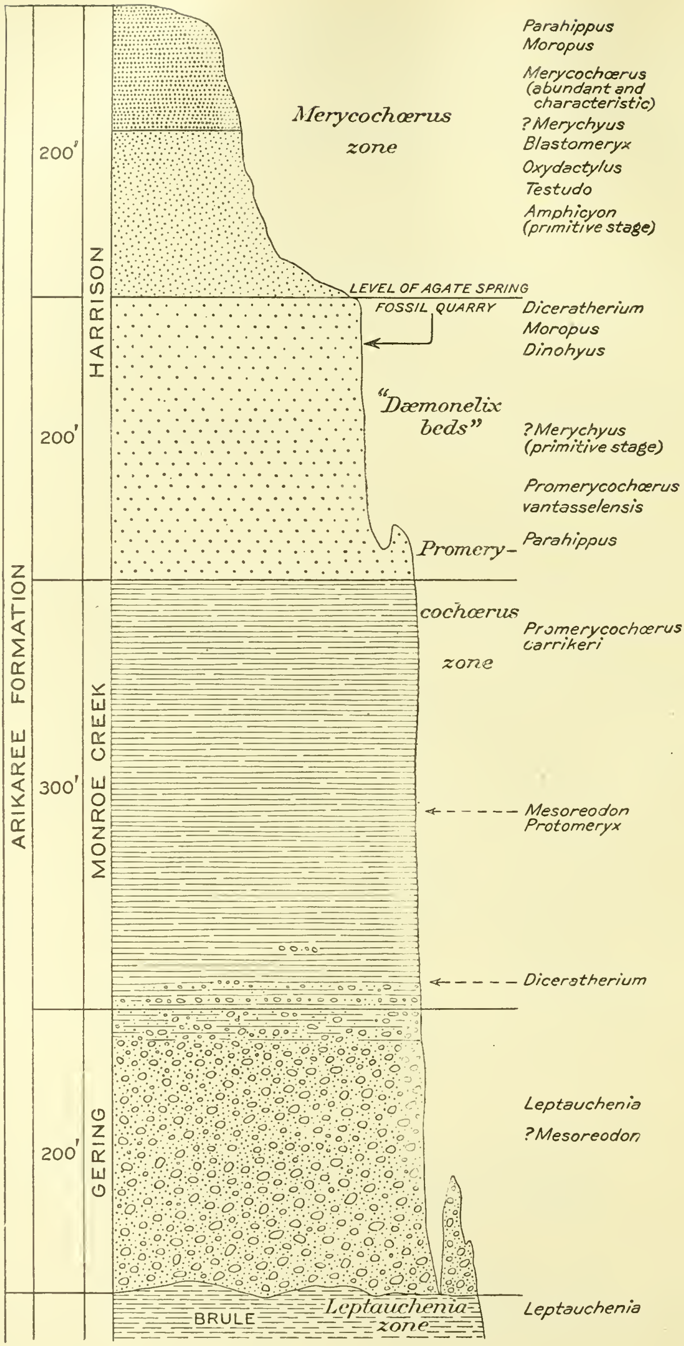


FIG. 13.—Columnar section of the Gering, Monroe Creek, and Harrison formations, based on Peterson's observations in western Nebraska. (See section A, Pl. II.)

WESTERLY SECTION.

(Figs. 13, 14.)

The recognition of this fauna[a] is the most important advance of recent mammalian paleontology in North America. As observed by Peterson,[b] continuing the observations of Hatcher,[c] in a section run through northwestern Nebraska and southeastern Wyoming, we find three distinct formations, as described below.

A. LOWER DIVISION.

(*a*) *Gering formation* (*or lower part of Monroe Creek*).—Among Artiodactyla-Oreodontidæ, *Mesoreodon*, *Leptauchenia*. The species of *Leptauchenia* are but slightly more progressive than those (*L. decora*, *L. nitida*) of the underlying *Leptauchenia* zone or upper part of the Brule clay.

(*b*) *Monroe Creek formation.*—Among Artiodactyla-Oreodontidæ, *Mesoreodon*, *Promerycochœrus*, *Phenacocœlus;* among Camelidæ,

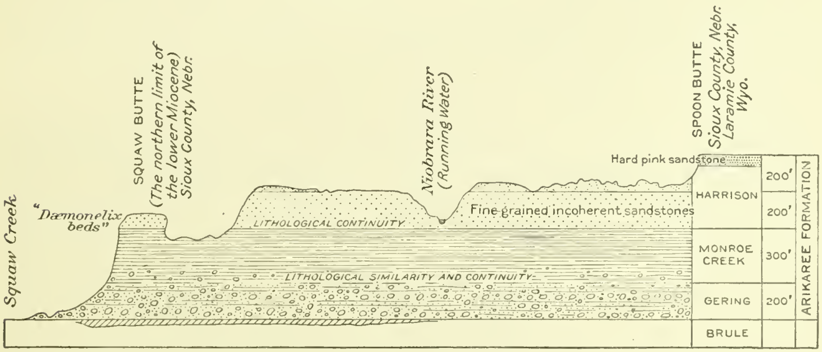


FIG. 14.—Diagrammatic section of the Gering, Monroe Creek, and Harrison formations of western Nebraska. Modified from Peterson, 1906. For the line of this section see section A, Pl. 11.

Protomeryx; among Rodentia, *Euhapsis platyceps;* among Canidæ, *Nothocyon;* among Rhinocerotidæ, *Diceratherium*.

(*c*) *Harrison formation, Hatcher.*—These are the "*Dæmonelix* beds" of Barbour. The great spirals or corkscrews to which the name *Dæmonelix* was applied are found to contain remains of the characteristic lower Miocene rodents, Castoridæ-*Steneofiber* (an aberrant castoroid), and are believed by Peterson[d] to represent the burrows of this rodent. The original theory of Barbour (1892) was that these corkscrews represent the spiral roots of some giant plant. Neither theory is entirely satisfactory. The Harrison forma-

[a] See Appendix, p. 91.

[b] The Miocene beds, etc.: Ann. Carnegie Mus., vol. 4, 1906, p. 23.

[c] Origin of the Oligocene and Miocene deposits of the Great Plains: Proc. Am. Philos. Soc., vol. 41. 1902, pp. 118–119.

[d] Mem. Carnegie Mus., vol. 2, 1905, pp. 139–191.

tion contains, among Oreodontidæ, *Promerycochœrus* (*P. vantasselensis*), *Phenacocœlus* (*P. typus*), also a primitive brachyodont stage of *Merychyus;* among Camelidæ, two brachyodont genera, namely, *Miolabis* and a related form, *Oxydactylus; Stenomylus*, a cameloid of the *Hypisodus* type;[a] among Hypertragulidæ, *Syndyoceras*,[b] which replaces *Protoceras* (of the upper Brule level); among Dicotylidæ, primitive species of *Desmathyus;* among Rodentia-Castoridæ, *Steneofiber*, very abundant (2 sp.); among Equidæ, *Parahippus;* among Mustelidæ, *Brachypsalis.*

(*d*) *Harrison formation, Agate Spring quarry.*—Near the middle of the Harrison formation is the extraordinarily rich deposit of this quarry, which gives us a nearly if not quite complete picture of the larger mammals of this region and period. So far as described by Peterson,[c] it contains, among Perissodactyla-Equidæ, *Parahippus;* among Rhinocerotidæ, *Diceratherium*, 2 species; among Chalicotheriidæ, *Moropus;* among Artiodactyla-Oreodontidæ, *Merychyus* and ?*Merycochœrus;* among Elotheriidæ, *Dinohyus*, a giant form similar to the large John Day types and probably the last of its family; among Carnivora-Canidæ, *Nothocyon*, *Amphicyon* (a very primitive form, its earliest appearance in America).

B. UPPER DIVISION.

(*e*) *Upper part of Harrison formation.*[d]—Among Artiodactyla-Oreodontidæ, *Merycochœrus* (first abundant appearance of this genus), *Merychyus;* among Camelidæ, ?*Miolabis* and *Oxydactylus*, 2 species; the first appearance of the family Cervidæ, genus *Blastomeryx*, a modernized selenodont artiodactyl; Dicotylidæ, *Desmathyus;* among Perissodactyla-Equidæ, *Parahippus*, a large brachyodont horse constituting the most abundant type and most characteristic stage; among Chalicotheriidæ, *Moropus;* among Carnivora-Mustelidæ, *Ælurocyon.* Also 2 species of *Testudo.*

EASTERLY SECTION.

(Fig. 12.)

About 90 miles farther east along Pine Ridge in northern Nebraska and on the south side of White River is the formation, also overlying the upper Brule clay, named by Matthew and Gidley[e] (1904) the Rosebud beds. This is the region of the typical Arikaree section of Darton, described and named in 1899. The section (fig. 12) was made by Albert Thomson, of the American Museum expedition of 1906.

---

[a] Peterson, op. cit.

[b] Barbour, E. H., Notice of a new fossil mammal from Sioux County, Nebr.: Nebraska Geol. Survey, vol. 2, pt. 3.

[c] The Miocene beds of western Nebraska, etc.: Ann. Carnegie Mus., vol. 4, 1906, pp. 21–72.

[d] Erroneously termed "Nebraska" in Peterson's first report. The Agate Spring fossil quarry: Ann. Carnegie Mus., vol. 3, 1906, p. 487.

[e] New or little known mammals from the Miocene of South Dakota: Bull. Am. Mus. Nat. Hist., vol. 20, 1904, pp. 241–268.

As analyzed by Matthew[a] it is to be noted that: (1) The Rosebud fauna contains no new immigrants, but is mainly a further development of the John Day fauna; all the animals exhibit slightly or decidedly more progressive stages. For example, the camels of the Monroe Creek, Harrison, and Rosebud are decidedly more advanced than anything from the upper part of the John Day, as are also the horses, carnivores, rodents, and oreodonts. (2) This fauna was distributed farther out in the Plains Region, a circumstance that may have differentiated it locally from the more westerly fauna of the Monroe Creek and Harrison formations, which was presumably near the sources of the water supply, forests, etc. This fact of local distribution may account for some differences in comparison with the Monroe Creek and Harrison lists above. These differences may be reduced or increased by further exploration.

A. LOWER PART OF ROSEBUD.

Homotaxis.—1, Lower part of Rosebud of Matthew; 2, Gering of Darton, Hatcher, and Peterson; 3, Monroe Creek of Hatcher; 4, Harrison of Hatcher; 5, Middle portion of "Martin Canyon beds" of Matthew, Colorado.

Fauna.[b]—Among Carnivora, *Nothocyon, Mesocyon, Enhydrocyon, Nimravus;* among Rodentia, *Entoptychus, Steneofiber, Euhapsis, Meniscomys, Lepus;* among Perissodactyla, *Parahippus, ?Anchitherium, Diceratherium;* among Artiodactyla, *Elotherium, Eporeodon, Mesoreodon, Promerycochœrus* (very abundant and characteristic), *Leptauchenia,* and *Hypertragulus.*

B. UPPER PART OF ROSEBUD.

Homotaxis.—1, Upper part of Rosebud of Matthew. 2, Deposits near Laramie Peak, Wyoming. 3, Upper part of Harrison of Peterson, western Nebraska. 4, Summit of "Martin Canyon beds" of Matthew, Colorado.

Fauna.—(1) Few species pass from the lower part of the Rosebud into the upper part. (2) The Elotheriidæ, Hypertragulidæ, and *Promerycochœrus* have probably disappeared. (3) The Diceratheriinæ continue. Among Carnivora, *Cynodesmus, Megalictis, Oligobunis.* Among Insectivora, *Arctoryctes* (a supposed member of the Chrysochloridæ). Among Rodentia-Geomyidæ, *Entoptychus, Lepus,* and a heteromyid. Among Perissodactyla, 2 families: *Parahippus,* other Equidæ, *Diceratherium.* Among Artiodactyla, 4 families: (*a*) Dicotylidæ, *Desmathyus;* (*b*) among Oreodontidæ, *Merychyus* is extremely abundant and characteristic; *Merycochœrus* also appears for the first time; (*c*) Camelidæ, *Protomeryx;* (*d*) Cervidæ, *Blastomeryx.*

[a] A lower Miocene fauna from South Dakota: Bull. Am. Mus. Nat. Hist., vol. 23, 1907, pp. 169-219.

[b] See Appendix, p. 91.

V. FIFTH FAUNAL PHASE.

Fresh migrations via Eurasia—First appearance of African Proboscidea, of true Felinæ among the Felidæ, of short-limbed Teleocerinæ among Rhinocerotoidea, animals occurring in the lower Miocene of Europe—Evidence of increasing summer droughts.

MIDDLE MIOCENE (EUROPE, ÉTAGES HELVÉTIEN, SARMATIEN, TORTONIEN).

FAUNAL CHANGES.

1. *North America.*—In the formations which are now commonly classed as middle Miocene, but which may prove to represent lower and middle Miocene, we meet another very profound change in the mammals of North America. This change is threefold: It consists (*a*) in the occurrence of more advanced evolutionary stages, among the Camelidæ and Equidæ especially; (*b*) in the extinction of many mammals characteristic of the Harrison or upper Rosebud or lower Arikaree, which we are here considering lower Miocene; (*c*) in the sudden appearance of a large number of new forms of African (Proboscidea) and Eurasiatic (e. g., Rhinocerotidæ, Teleocerinæ, Pecora) origin. The appearance of several modernized selenodont artiodactyls or Pecora must have effected a change in the external aspects of the fauna which was only less striking than that caused by the mastodons and the bulky rhinoceroses.

2. *Europe.*—As regards (*b*) and (*c*), a similar extinction and sudden appearance also mark the base of the European Miocene, the Langhien or Burdigalien as represented by the Sables de l'Orléanais of Europe. The conclusion is that these North American middle Miocene formations contain animals which first appear in the lower Miocene of Europe, just as the American lower Miocene contains animals which first appear in the upper Oligocene of Europe. At least, this is the hypothesis on which our correlations are based at present, allowing considerable time for migration from the old to the new world.

14. DEEP RIVER SEQUENCE, SCOTT; TICHOLEPTUS ZONE, COPE.

(Figs. 1, 10; Pl. I.)

HOMOTAXIS.

America.—This is in large part the "Loup Fork fauna" of Cope's descriptions, because his materials were chiefly from this level in Colorado and Oregon beds. (*a*) Central Plains: 1, Horizon E of Hayden and Leidy; 2, "Pawnee Creek beds" of Matthew, northeastern Colorado (75 feet), immediately overlying the Harrison; 3, "Panhandle beds" of Gidley, northwestern Texas. (*b*) Northern Plains: 4, Upper part of Deep River sequence (Smith Creek) or *Ticholeptus* zone (of Cope), Montana; 5, "Flint Creek beds" of

Douglass (150 feet), Montana. (*c*) Mountain Region: 6, Mascall formation, Oregon (lower part, 1,000 feet), capping the Columbia River lava (1,000 feet), which in turn overlies the John Day formation. The Colorado (Matthew[a]) and Montana (Scott,[b] Douglass[c]) faunæ are the best known and are closely equivalent in age.

Europe.—Homotaxis with Europe is provisional, owing to: (1) Uncertainty as to what we should regard as the base of the American Miocene; (2) uncertainty as to the speed or rate of migration from Europe. The new mammals of this stage (viz, Proboscidea, Teleocerinæ, and Pecora) are all from Europe, where they form the chief characteristics of the lower Miocene; but we may suppose that these animals occupied a portion of the lower Miocene period in migrating from western Europe to North America.

FAUNA.[d]

1. Scott first (1893[e]) fully characterized the upper Deep River fauna of Montana as prior to the so-called "Loup Fork" of Colorado.

2. Matthew[f] first (1901) clearly distinguished the fauna of our so-called middle Miocene ("Pawnee Creek") from that of the upper Miocene or typical Niobrara River "Loup Fork" of Hayden, and the above correlations are chiefly due to him.

3. Its negative characters are: Nonoccurrence of Artiodactyla-Elotheriidæ and Hypertragulidæ (which apparently became extinct during the lower Rosebud); of Perissodactyla-Diceratheriinæ (which apparently became extinct during the upper Rosebud).

4. Its positive or new characters are: (1) The first appearance of Proboscidea by migration from Africa. (2) By migration from western Europe or Eurasia: Among Carnivora 2 new and distinctive Eurasiatic subfamilies—(*a*) true Felidæ-Felinæ, *Pseudælurus;* (*b*) Canidæ-Amphicyoninæ, *Amphicyon.* Among Perissodactyla-Rhinocerotoidea, a member of the Teleocerinæ closely similar to the lower Miocene *Teleoceras aurelianensis* of France. Among Artiodactyla-Cervidæ, *Palæomeryx;* other peculiarly American modernized ruminants, *Merycodus* (family Antilocapridæ), date from this stage. Among Rodentia the new family Mylagaulidæ (also American) appears. Thus in our so-called middle Miocene the peculiarly American Hypertragulidæ disappear; the European Cervidæ and the peculiarly American Merycodontinæ take their places.

[a] Matthew, W. D., Fossil mammals of the Tertiary of northwestern Colorado: Mem. Am. Mus. Nat. Hist., vol. 1, pt. 7, Nov., 1901, pp. 355–447.

[b] Scott, W. B., The Mammalia of the Deep River beds: Trans. Am. Philos. Soc., n. s., vol. 18, 1895, pp. 55–185.

[c] Douglass, Earl, The Neocene lake beds of western Montana: Univ. Montana, doctorate thesis June, 1899. New vertebrates from the Montana territory: Ann. Carnegie Mus., vol. 2, 1903.

[d] See Appendix, p. 91.

[e] Scott, W. B. The mammals of the Deep River beds: Am. Naturalist, vol. 27, 1893, pp. 659–662. The Mammalia of the Deep River beds: Trans. Am. Philos. Soc., n. s., vol. 18, 1895, pp. 55–185.

[f] Matthew, W. D., op. cit., pp. 358–374.

Plains fauna.—Of local evolution on the Great Plains the Equidæ exhibit, as the most distinctive genus, the first of the Hippotheriinæ or *Merychippus* stage of horses with subhypsodont molar teeth; the large brachyodont *Hypohippus* is also found, as well as *Parahippus*. Among Rhinocerotidæ, the hornless *Aphelops* first occurs, also *Teleoceras*. Among Tapiridæ, *Tapiravus*. Among Camelidæ, *Miolabis* continues, *Protolabis* appears, and *Alticamelus* succeeds *Oxydactylus*. Among Oreodontidæ, the family reaches a climax of differentiation in 7 genera, including *Merychyus* and *Merycochœrus*, but adding the very characteristic genera *Ticholeptus* and *Cyclopidius*, which are probably direct descendants of *Eporeodon* and *Leptauchenia* of the preceding stage. Among Rodentia-Mylagaulidæ, *Mylagaulus*, *Ceratogaulus*. Among Canidæ, *Cynarctus*, *Amphicyon*, and other less aberrant genera.

Mountain Region fauna of the Mascall formation.—The Mascall formation of Oregon, overlying the Columbia River lava and subjacent John Day, is partly homotaxial with the middle and upper Miocene. The fauna, sparsely known, includes very primitive horses with short-crowned teeth (*Archæohippus*, *Parahippus*); also the more progressive *Merychippus*, which is characteristically middle Miocene, although it persists into the upper Miocene. We find *Miolabis* among Camelidæ. Among Cervidæ, *Palæomeryx*. Among Proboscidea, *Trilophodon*. An ungual phalanx of the Edentata-Gravigrada type is certainly reported from these beds (Sinclair); the true South American Gravigrada are first known to occur in the middle Pliocene (Blanco formation of Texas).

MOUNTAIN REGION FLORA.

The flora seems to point to a more recent age for these beds, but American floræ generally are more progressive than the vertebrate fauna. The Mascall flora was considered upper Miocene by Lesquereux. Knowlton[a] also concludes that the flora is of upper Miocene age; from his list cited by Merriam[b] (1901), Hollick[c] observes:

> I judge that the meteorological, climatal, and physiographic conditions indicated would be comparable to those now met with on the Atlantic coastal plain at about the latitude of the Carolinas. A majority of the trees, such as *Salix*, *Quercus*, *Planus*, *Aralia*, *Acer*, *Prunus*, etc., belong to the Temperate Zone, and represent a flora similar to that of this vicinity [New York, lat. 42° N.]. Accompanying these, however, are a few of more southern distribution, such as *Taxodium*, *Laurus*, *Sapindus*, and *Ficus?*, which indicate that the flora as a whole should be regarded as warm-temperate. The indicated moisture factor is a little more difficult to determine. *Marsilea* is an aquatic plant, and the characteristic habitat of *Taxodium* is swamp land, while the other genera might represent either lowland or upland species.

---

[a] Knowlton, F. H., Fossil flora of the John Day basin: Bull. U. S. Geol. Survey No. 204, 1902, p. 108.

[b] Merriam, J. C., A contribution to the geology of the John Day basin: Bull. Dept. Geology, Univ. California, vol. 2, 1901, pp. 308, 309.

[c] Letter of February 6, 1906.

UPPER MIOCENE (EUROPE, ÉTAGE PONTIEN).

15. OGALALLA FORMATION (IN PART); PROCAMELUS ZONE.

(Figs. 1, 10; Pl. I.)

HOMOTAXIS AND SYNONYMY.

North America.—This includes the "Loup Fork" of Leidy, Marsh, also of Scott and Osborn, in part. 1, "Nebraska" of Scott, 1894, western Nebraska.[a] 2, *Cosoryx* zone, Scott,[b] 1894. (The genus *Cosoryx* is preoccupied by *Merycodus,* so it appears that this name can not be used.) 3, Ogalalla and Arikaree of Darton (in part), 1899, western Nebraska. 4, *Protohippus* zone of Osborn, 1907. 5, "Santa Fe marls" of Cope, New Mexico. 6, "Clarendon beds" of Gidley, Llano Estacado, northwestern Texas (75 feet). Northern Plains: 7, "Madison Valley beds" of Douglass, Montana (1,200 feet).

Europe.—Étage Pontien, Pikermi, Eppelsheim. The so-called "Loup Fork mammals," although including *Hipparion,* are not quite so modernized as those of Eppelsheim and Pikermi, which should be regarded as lower Pliocene.

This fauna has become universally known as the "Loup Fork fauna" (Cope, 1877), owing to errors on the part of Hayden, Leidy, Cope, and their successors, arising from the confusion of late Miocene and upper Pliocene faunæ. But, as shown fully on page 84, the term "Loup Fork" is equivalent to "Loup River," and the latter term was originally applied so as to include an upper Pliocene or lower Pleistocene formation containing *Elephas imperator.*

FAUNA.[c]

This is one of the best known, most widely distributed, and most characteristic faunæ in all the Tertiary series. There is no evidence of a fresh Eurasiatic migration, but rather of rapid local evolution. The genus *Protohippus* distinguishes it clearly from the middle Miocene, which contains *Merychippus* only. Other new distinctive genera are the camels *Procamelus* and *Pliauchenia,* the horse *Neohipparion,* and the rhinoceros *Peraceras.* The wide distribution of a similar fauna at this stage indicates widespread conditions of aridity and a uniformly favorable environment, summer droughts probably lengthening and eolian deposits increasing. From Montana on the northwest and Texas on the southwest to Nebraska in the central west we find a very similar list of animals; so the homo-

---

[a] Bull. Geol. Soc. America, vol. 5, 1894, p. 595.

[b] Under a misapprehension as to Scott's definition of the term "Nebraska," both Hatcher and Peterson first applied this term to a part of the lower Arikaree or lower Miocene.

[c] Matthew, W. D., and Gidley, J. W., New or little known mammals from the Miocene of South Dakota etc.: Bull. Am. Mus. Nat. Hist., vol. 20, 1904, pp. 241–268. See Appendix, p. 91.

taxis of the American horizons "Nebraska," "Clarendon beds," "Santa Fe marls," and "Madison Valley beds" is singularly well established.

Among Rodentia-Mylagaulidæ, 1 genus. Among Sciuridæ, 2 genera. Among Carnivora-Canidæ, *Ælurodon*, *Cynodesmus*(?), *Borophagus*, *Dinocyon*(?), and *Ischyrocyon*. Among Mustelidæ, *Mustela*, *Lutra*, *Potamotherium*, *Brachypsalis*, *Putorius*. Among Felidæ, *Pseudælurus* (*Felis* of Leidy), and large machærodonts of uncertain genus. Among Procyonidæ, *Leptarctus*. Among Perissodactyla, 3 families: (*a*) among Equidæ (5 genera), *Protohippus* (5 or more species), *Neohipparion* (5–12 species) with long crowned teeth, *Merychippus* persisting with intermediate teeth, *Hypohippus* and *Parahippus* (Montana) persisting with short-crowned teeth; (*b*) among Rhinocerotidæ-Teleocerinæ, 2 genera of the short-limbed type occur—*Teleoceras*, *Peraceras*, also *Aphelops ceratorhinus*; (*c*) among Tapiridæ, *Tapiravus*. Among Artiodactyla, 5 families: (*a*) Camelidæ, including *Pliauchenia* (its first appearance, 2 or more species), *Procamelus* (its first appearance, 2–7 species); (*b*) among Oreodontidæ, *Merycochœrus* (2 species, Montana), *Merychyus*, *Pronomotherium*; (*c*) among Merycodontinæ, *Merycodus*; (*d*) among Dicotylidæ, *Prosthennops* (Montana); (*e*) among Cervidæ, *Palæomeryx* (5 species), *Blastomeryx*. Among Proboscidea there occur the long-jawed types analogous to *Trilophodon angustidens* of Europe.

LAST PHASE OF MIOCENE OR FIRST PHASE OF PLIOCENE (EUROPE, ÉTAGES PONTIEN, MESSINIEN).

A late phase of Miocene, or early phase of Pliocene, is the deposit on Republican River, in northern Kansas. It is, provisionally and subject to further exploration, distinguished (Matthew) from the so-called "Loup Fork," or "Nebraska," of Scott. Its fauna presents certain parallels with the Pikermi and Eppelsheim fauna (placed by Depéret in the upper Miocene) of Europe, even if not of more recent age. It is widely separate from a second and much later phase, represented in the Blanco formation of northwestern Texas, which is much more recent in its fauna and is here regarded as middle Pliocene.

16. OGALALLA FORMATION (IN PART); PERACERAS ZONE.

(Figs. 1, 10; Pl. I.)

HOMOTAXIS.

America.—1, Upper "Loup Fork" (100 feet) of Republican River, northwestern Kansas. 2, Ogalalla formation (typical), Darton, of southwestern Nebraska. 3, "Archer formation" of Florida (in part). 4, Rattlesnake formation of John Day Valley, Oregon.

Europe.—Pontien: Eppelsheim, in northern Europe; Pikermi, in Greece; Mont Léberon, Vaucluse, France.

FAUNA.[a]

From our present knowledge, the close of the Miocene or advent of the Pliocene may be characterized: Negatively, (1) by the absence of Artiodactyla-Oreodontidæ and the rarity of *Merychyus*, *Merycochœrus*, etc., which thus far are represented only by fragmentary specimens; (2) by some reduction in the number of Camelidæ (in this family *Pliauchenia* is now the characteristic genus); (3) by the rarity of the browsing horses (*Hypohippus*); (4) by the disappearance of the Perissodactyla-Chalicotheriidæ. Probably some of these absent forms will be unearthed by future exploration. Positively, (1) by the more advanced evolution of the Rhinocerotidæ in progressive species of *Teleoceras*, *Peraceras*, and *Aphelops;* (2) by more progressive but still long-jawed forms of Proboscidea-Mastodontidæ, with four or more crests on the molar teeth.

Characteristic animals are: Among Rodentia-Mylagaulidæ, *Mylagaulus*, also a new and more specialized genus, *Epigaulus* Gidley; among Castoridæ, *Dipoides;* among Carnivora, both Felinæ and Machærodontinæ; among Canidæ, *Ælurodon*, *?Dinocyon;* among Rhinocerotidæ, *Teleoceras*, *Peraceras*, *Aphelops*, including the progressive species *A. malacorhinus;* among Equidæ, *Protohippus*; among Artiodactyla, 4 families, (*a*) Dicotylidæ, *Prosthenops;* (*b*) Camelidæ, *Procamelus*, *Pliauchenia* (a large form), *Alticamelus* (typical in the Rattlesnake formation, Oregon); (*c*) Merycodontinæ, *Merycodus*; (*d*) Cervidæ, *Blastomeryx;* among Proboscidea, *Trilophodon campester* and *T. euhypodon* are recorded, both with long jaws.

16a. RATTLESNAKE FORMATION (200 FEET) OF JOHN DAY VALLEY, OREGON.

(Figs. 1, 10; Pl. I.)

The sparsely known fauna of this formation, as determined by Merriam,[b] Sinclair, and Gidley, contains the tortoise *Clemmys hesperia* Hay. Among mammals: Perissodactyla, (*a*) Equidæ, *Pliohippus supremus*, (*b*) Rhinocerotidæ-?Teleocerinæ, indet.; Artiodactyla, (*a*) Dicotylidæ, indet., (*b*) Camelidæ, *Alticamelus altus* (the typical form), also *Pliauchenia;* large species of *Procamelus* still survive.

PLIOCENE.

Homotaxis.—Pliocene homotaxis must be prefaced by the statement that the American fauna is sparsely and imperfectly known as yet, and that correlations with Europe (étages Messinien, Plaisancien, Astien) are very provisional. The gaps will undoubtedly be filled eventually.

---

[a] See Appendix, p. 115.

[b] A contribution to the geology of the John Day basin: Bull. Dept. Geology, Univ. California, vol. 2, 1901, pp. 310-312.

VI. SIXTH FAUNAL PHASE.

Land connection with South America reestablished—Invasion of South American Edentata-Gravigrada and Glyptodontia—Migration of North American mammals to South America.

Decidedly distinct and more recent than either the typical "Loup Fork," the upper "Loup Fork" deposits on Republican River, Kansas, or the Rattlesnake formation, is the Blanco formation of Texas.

MIDDLE PLIOCENE OR SECOND PHASE (EUROPE, ÉTAGE ASTIEN).

17. BLANCO FORMATION; GLYPTOTHERIUM ZONE.

(Fig. 15; Pl. I.)

HOMOTAXIS.

North America.—Plains fauna: 1, Blanco formation of Cummins,[a] Cope,[b] Gidley[c] (100 feet), Llano Estacado of Texas. 2, Ogalalla formation of Darton (? in part), northwestern Nebraska.

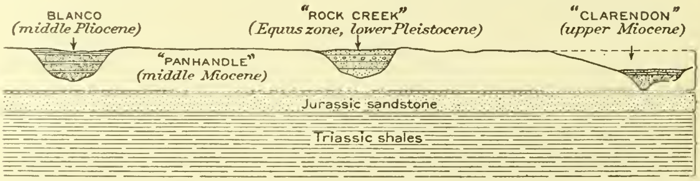


Fig. 15.—Diagrammatic section of the Staked Plains (Llano Estacado), Texas, showing the relations of the "Clarendon" (or *Protohippus* zone), "Rock Creek" (or *Equus* zone), and Blanco (or *Glyptotherium* zone) to the underlying "Panhandle" (or ? *Merycochœrus* zone). After J. W. Gidley, 1908.

FAUNA.[d]

This faunal phase is clearly characterized negatively: (1) By the undoubted extinction of the Oreodontidæ, (2) by the apparent extinction of the Rhinocerotidæ, (3) by the apparent but not yet fully demonstrated absence of the forest or browsing horse *Hypohippus*. It is distinguished from the upper Pliocene of Europe (étage Sicilien) by being antecedent to the appearance of the genera *Equus* and *Elephas*. It is characterized very positively: In Texas (4) by the first appearance of South American Edentata-Gravigrada, *Mylodon*, *Megalonyx;* (5) also by the first appearance of Glyptodontia *Glyptotherium;* (6) in Texas and Nebraska by short-jawed Proboscidea with molar teeth in some respects resembling the *Stegodon* type, *Dibelodon mirificus*.

[a] Cummins, W. F., Notes on the geology of northwest Texas: Third Ann. Rept. Geol. Survey Texas, 1891 (1892), pp. 129–200; Fourth Ann. Rept., 1892 (1893), pp. 179–238.

[b] Cope, E. D., A preliminary report on the vertebrate paleontology of the Llano Estacado: Fourth Ann. Rept. Geol. Survey Texas, 1892 (1893), pp. 1–136.

[c] Gidley, J. W., The fresh-water Tertiary of northwestern Texas, etc.: Bull. Am. Mus. Nat. Hist., vol. 19, 1903 (Blanco), pp. 624–632.

[d] See Appendix, p. 91.

The fossiliferous horizon on Loup River in Nebraska which yielded *Dibelodon mirificus* has not been recently explored. The fauna is sparsely known from the Blanco formation of Texas. It includes among Carnivora-Canidæ, *Borophagus, Amphicyon* being doubtfully present; among Mustelidæ, *Canimartes;* among Felidæ, *Felis hillianus*, the earliest positively known appearance of *Felis*. Among Proboscidea from this level is *Dibelodon mirificus* (Nebraska, Texas); among Artiodactyla-Dicotylidæ, the large cursorial peccary *Platygonus* first appears; among Camelidæ, *Pliauchenia* of very large size; among Equidæ, *Neohipparion* and *Protohippus* continue; among Edentata-Glyptodontia, *Glyptotherium* resembles *Panochthus* of the Pampean in type, but is less specialized; *Megalonyx* and *Mylodon* occur.

UPPER PLIOCENE OR LOWER PLEISTOCENE.

18. ELEPHAS IMPERATOR ZONE.

HOMOTAXIS.

North America.—1, Horizon F of Hayden and Leidy, upper part only. 2, "Loup River" of Meek and Hayden, 1861–62, Nebraska. 3, Certain formations (unnamed) in Texas and Mexico, containing *Elephas imperator.*

Europe.—In Europe the uppermost Pliocene is distinguished by the disappearance of *Hipparion* and the advent of *Elephas* (*E. meridionalis*) and *Equus* (*E. stenonis*).

HISTORY AND SYNONYMY.

According to the decision of the committee on geologic names of the Geological Survey, the typical beds of this stage may for the present be known as upper Pliocene or *Elephas imperator* zone. The ground for this decision is the confusion in the application of the terms "Loup River" and "Loup Fork," which apply to the same stream; also the confusion in the usage of the term "Loup Fork."

Horizon F, or the typical "Loup River beds," on "Loup Fork of Platte River, extending north to Niobrara River and south to an unknown distance beyond the Platte," were first characterized by Meek and Hayden[a] (1861–62) as follows: "Fine loose sand, with some layers of limestone—contains bones of *Canis, Felis, Castor, Equus, Mastodon, Testudo*, etc., some of which are scarcely distinguishable from living species." Of the bones collected in this locality Leidy[b] observed in 1869: "Other remains of elephants, as Doctor Hayden supposes them to be, he observed in association with those of *Mastodon mirificus, Equus excelsus*, and *Hipparion* at the head of the Loup Fork branch of the Platte River; also between this point and

[a] Proc. Acad. Nat. Sci. Philadelphia, vol. 13, 1861 (1862), p. 433.

[b] Extinct mammalian fauna of Dakota and Nebraska, 1869, p. 255.

the Niobrara River and on the latter." These species were determined by Leidy as follows: *Elephas imperator* Leidy, *Mastodon mirificus* Leidy, *Equus excelsus*.

The type of *Equus excelsus* is elsewhere stated to be from the "Pawnee Loup branch of the Platte or Niobrara River." In the same article [a] a somewhat fuller description of the "Loup River beds" makes them include all the deposits down to the top of the White River group, and the faunal list contains several Miocene genera in addition to the more modern types first cited.

The term "Loup River" was again employed by Hayden in 1862, 1869 (introduction to Leidy's memoir), 1871, and 1873.

It is unfortunate that this upper Pliocene or lower Pleistocene horizon, although fairly well defined both geographically and faunistically, should have been confused by Hayden and Leidy themselves (see 1869, pp. 15–21) with the very much older horizon or true upper Miocene, as part of their Horizon F, including the very rich upper Miocene faunal list. Thus Cope,[b] while referring to the very same Nebraska fauna which was described by Leidy [c] in 1858, applies the terms "Loup Fork epoch" and "Loup Fork beds" to the "Santa Fe marls" of New Mexico. The error thus spread into all the subsequent literature. It appears, therefore, that: (1) "Loup River" is the original name. (2) "Loup River" originally included an upper Pliocene or lower Pleistocene horizon. (3) "Loup Fork" is essentially the same name; it is a synonym of "Loup River;" it was defined in still another sense and has been generally used in a very different sense, and must drop out of use entirely.

PLEISTOCENE.

VII. SEVENTH FAUNAL PHASE.

Increasing cold, moisture, and forestation—Third modernization by a gradual Eurasiatic invasion of hardy, forest, fluviatile, mountain (alpine), plains, and barren-ground fauna—Gradual extinction of the larger Ungulata, of the native North American stocks, of the South American invading stocks, of the Miocene invading Eurasiatic and African stocks.

LOWER PLEISTOCENE (PREGLACIAL).

Our knowledge of the mammals in this period is still confined to the western plains and mountains.

The American Pleistocene begins either with the *Elephas imperator* zone (referred above to the upper Pliocene) or with the *Equus* zone. The exact position of the *Elephas imperator* zone, also the question whether it is of the same age as the *Equus* zone, remain to be determined. In the present review only a few of the characteristic Pleistocene deposits will be included, because the subject of Pleistocene correlation and succession is in its infancy.

---

[a] Meek and Hayden, Proc. Acad. Nat. Sci. Philadelphia, vol. 13, 1861 (1862), p. 435.
[b] Rept. U. S. Geog. Survey W. 100th Mer. (Wheeler), pt. 2, 1877, pp. 20, 361.
[c] Proc. Acad. Nat. Sci. Philadelphia, 1858, p. 20.

19. EQUUS ZONE.

HOMOTAXIS.

America.—Plains and border fauna. 1, "Sheridan formation" (Scott[a]) or, 2, *Equus* zone, Hay Springs, northwestern Nebraska. 3, "Rock Creek beds" (Gidley[b]), Tule Canyon, Llano Estacado, Texas. Widely scattered and numerous deposits in Great Plains and Mountain regions, some of which have received distinct formation names.

Europe.—Preglacial. Forest beds of Norfolk (England); St. Prest (Eure-et-Loire); Durfort (Gard), containing *Elephas meridionalis* (its last appearance). The European fauna of this period includes (Osborn,[c] 1900) 12 Pliocene species, 32 Pleistocene species and races, now extinct, and 17 living species (7 Insectivora, 1 Cheiroptera.)

FAUNA.[d]

It is noteworthy (Matthew,[e] 1902) that chiefly the Plains fauna and no purely forest fauna of this phase is known, a fact which may account for the nonappearance of certain forest-living types. There is some evidence of increasing moisture and of the renewal of streams and of forests; for example, at Hay Springs, northwestern Nebraska (a slightly earlier phase), the presence of streams is indicated by *Fiber*, of wooded rivers by *Castoroides*. In Silver Lake, Oregon (a slightly more recent phase), a partly fluviatile and wooded country is indicated by *Fiber*, *Lutra*, *Castor*, and *Castoroides*.

The mammal fauna [e] is characterized negatively (1) by the absence or disappearance of Perissodactyla-Rhinocerotidæ, (2) by the nonappearance of Bovidæ or Ursidæ. It is characterized positively by the first appearance (3) among Equidæ, of *Equus* (3 species); (4) among Proboscidea, of *Elephas* (2 species), *E. columbi*, *E. imperator*;[f] (5) among Artiodactyla, of the distinctively American genus *Antilocapra;* among Camelidæ, of *Camelus;* among Rodentia, of 6 new modern genera and the first appearance of the extinct *Castoroides.*

More in detail, among Rodentia of Nebraska and Oregon occur 8 existing genera of the same region, *Arvicola*, *Fiber*, *Thomomys*, *Geomys*, *Cynomys*, *Castor*, *Lepus*, and *Castoroides;* among Carnivora-Canidæ, *Canis* (3 species); among Mustelidæ, *Lutra;* among Felidæ, *Felis;* among Edentata, *Mylodon* and *Paramylodon*[g] (plains or river-

[a] Bull. Geol. Soc. America, vol. 9, 1898, p. 406.

[b] The fresh-water Tertiary of northwestern Texas: Bull. Am. Mus. Nat. Hist., vol. 19, 1903, p. 622.

[c] Correlation, etc.: Ann. New York Acad. Sci., vol. 13, 1900, p. 38.

[d] See Appendix, p. 91.

[e] Matthew, W. D., List of the Pleistocene fauna from Hay Springs, Nebraska: Bull. Am. Mus. Nat. Hist., vol. 16, art. 24, Sept. 25, 1902, pp. 317-322. Cope, E. D., The Silver Lake of Oregon and its region: Am. Naturalist, vol. 23, 1889, pp. 970-982.

[f] As noted on p. 83, *E. imperator* may represent a late Pliocene phase.

[g] Brown, Barnum, Bull. Am. Mus. Nat. Hist., vol. 19, 1903, pp. 569-583

border types); among Perissodactyla-Equinæ, only 3 species; among Artiodactyla, 4 families: (*a*) Camelidæ, *Eschatius, Camelops* (2 species), *Camelus;* (*b*) Dicotylidæ, *Platygonus;* (*c*) Antilocapridæ, *Antilocapra* (first appearance); (*d*) Merycodontinæ (last appearance of this peculiarly American subfamily, genus *Capromeryx*); among Proboscidea, *Elephas columbi, E. imperator.* In the "Rock Creek beds" of Texas is found a supposed *Dinocyon* (*Borophagus*) or one of the Ursidæ.

MIDDLE PLEISTOCENE (GLACIAL).

GENERAL CHARACTERS.

Our knowledge of the American mammals now for the first time becomes continental because it represents deposits in all parts of North America.

The general characters of the middle Pleistocene as a whole may be summarized as follows:

1. This long period, which will eventually be divided into faunal substages, as in Europe, is distinguished negatively by the absence of the lower Pleistocene mammals (1) *Elephas imperator* and (2) Artiodactyla-Merycodontinæ, and (3) by the gradual extinction of the resident large quadrupeds.

2. It is marked chiefly by the gradual invasion of a Eurasian hardy and boreal fauna and thus distinguished positively by the first recorded appearance (1) of Ursidæ; (2) of Bovidæ—(*a*) Ovinæ, (*b*) Bovinæ, (*c*) Rupricaprinæ; (3) of 3 genera of the larger northern Cervidæ, namely, *Alces, Odocoileus, Cervus* (it is noteworthy that *Rangifer* does not appear in our mid-Pleistocene); (4) among Proboscidea, *Elephas primigenius* and *E. columbi* succeed *E. imperator*, and the appearance of *Mastodon americanus* is first recorded.

3. The hardy forest and glade fauna both east and west increase in number and variety, including the Cervidæ and Ursidæ.

4. The resident plains and forest-border grass-eating forms (Equidæ, Camelidæ, Elephantinæ) diminish in number and gradually disappear.

5. Among all the larger Carnivora and Herbivora only 3 resident families, namely, the Canidæ, Dicotylidæ, and Antilocapridæ, survive.

6. Thus all the less hardy previously invading Eurasiatic, South American, and native North American animals disappear.

7. Thus again we note the gradual extinction (1) among Edentata of the South American Gravigrada and Glyptodontia, (2) among Perissodactyla of the indigenous North American Tapiridæ and Equidæ, among Camelidæ of *Camelus*, among Carnivora of the Machærodontinæ or saber-tooths; (3) among Eurasiatic forms of the Elephantinæ.

8. The question of latitude, or more northerly or southerly distribution, becomes more important on account of the increasing cold.

The divisions of the mid-Pleistocene will ultimately be clearly marked off, first by the successive disappearance and extinction of the less hardy lower Pleistocene forms, second by the appearance or invasion of the more hardy modernized forms.

The following table is merely approximate:

Order of appearance and disappearance of lower Pleistocene forms.

APPEARANCE.	DISAPPEARANCE.
Early Pleistocene	*Early Pleistocene.*
Mylodon (central).	Elephas imperator.
Paramylodon.	Capromeryx.
Platygonus.	?Paramylodon.
Elephas columbi.	*Mid-Pleistocene.*
Antilocapra.	Camelus.
Camelus.	Mylodon.
Mid-Pleistocene.	Megalonyx.
Elephas primigenius.	Tapirus.
Mastodon.	Arctotherium.
Odocoileus.	Elephas columbi.
Haploceras.	Elephas primigenius.
Erethizon.	*Upper mid-Pleistocene.*
Bison.	Smilodontopsis.
Alces.	Mastodon.
Ovibos.	Equus.
Cervus (late).	Mylohyus.
Ursus (late).	
Rangifer (late).	

EARLY PHASES OF THE MIDDLE PLEISTOCENE.

The earliest phase, corresponding with the earliest mid-Pleistocene of Europe, is probably at present unrecognized in America. Other early phases of the middle Pleistocene may be provisionally distinguished as follows: (1) The true European stag *Cervus* does not appear; (2) the Camelidæ, Equidæ, Tapiridæ, Edentata-Gravigrada, and Elephantidæ still survive; (3) many extinct species of modern genera and many surviving modern species appear.

Port Kennedy cave, Pennsylvania.—The Port Kennedy cave [a] has yielded 54 species of mammals, 40 of which are now extinct. From an analysis of its fauna, Barnum Brown [b] is inclined to place it in the early part of the mid-Pleistocene. The climate was apparently temperate. (1) It lacks the early Pleistocene genera *Elephas* and *Camelus*, but the latter has thus far not been found in eastern deposits at all. (2) Among surviving lower Pleistocene forms it includes (*a*) of the Machærodontinæ, 2 species; (*b*) of the Edentata, 2 genera,

[a] Mercer, H. C., The bone cave at Port Kennedy, Pennsylvania: Jour. Acad. Nat. Sci. Philadelphia, vol. 11, pt. 2, 1899.

[b] Brown, Barnum, The Conard fissure, a Pleistocene bone deposit in northern Arkansas: Mem. Am. Mus. Nat. Hist., vol. 9, 1908, pp. 157-208.

Megalonyx, Mylodon; (*c*) of the Perissodactyla, *Equus*, 2 species, *Tapirus;* (*d*) of the Dicotylidæ, *Mylohyus*. (3) Among newly entering northern forms are: (*a*) *Odocoileus;* (*b*) *Ursus*, 2 species; (*c*) *Erethizon* (the first recorded appearance of the Hystricomorpha in North America). (4) We note the absence of Bovidæ.

Twelvemile Creek, Kansas.—On the plains of western Kansas, in Logan County, on Twelvemile Creek, a tributary of Smoky Hill River, is a deposit formerly considered by Williston[a] as of lower Pleistocene age, but now known to be of mid-Pleistocene age. In the blue-gray marl underlying the recent plains marl are recorded *Elephas primigenius* (*?E. columbi*), *Platygonus compressus*, and a number of specimens of *Bison occidentalis* (Lucas). Among Primates, *Homo* is indicated[b] by the occurrence of an arrowhead certainly associated with the skeleton of *Bison occidentalis* and believed by Williston to be in situ.

SUBSEQUENT PHASES OF THE MIDDLE PLEISTOCENE.

HOMOTAXIS.

America.—Potter Creek cave, Shasta County, Cal.; Silver Lake, Oregon.

ENVIRONMENT.

Environmental conditions on the Pacific coast were quite different from those in the Middle and Eastern States: (1) All glaciation on the Pacific coast was comparatively late in the Pleistocene and of the alpine type (Sinclair). It is quite possible, therefore, that many types of mammals (elephants, mastodons, camels, bisons) survived in the comparatively mild climate of the Pacific coast after they had become extinct in more easterly regions.

FAUNA.

Potter Creek cave.—The very rich Potter Creek cave fauna is regarded by Merriam and Sinclair[c] as a late phase of the middle Pleistocene, or even as late as the last quarter of the Pleistocene. It contains 37 genera and 49 species of mammals, of which 8 genera and 22 species are extinct, 3 are doubtfully extinct, and 21 are still existing. It is chiefly a forest fauna; forest types are numerous and plains types are lacking.

Positively we note the survival or presence of the edentates *Megalonyx* and *Nototherium;* also of *Equus* and *Elephas*. Among Artio-

---

[a] Williston, S. W., The Pleistocene of Kansas: Univ. Geol. Survey Kansas, vol. 2, 1897, p. 300.

[b] Williston, S. W., On the occurrence of an arrowhead with bones of an extinct bison: Trans. Intern. Congress of Americanists, 1902, p. 335.

[c] Sinclair, W. J., A preliminary account of the exploration of the Potter Creek cave, Shasta County, Cal.: Science, n. s., vol. 17, No. 435, May 1, 1903, pp. 708–712. The exploration of the Potter Creek cave: Univ. California, Publ. Am. Arch. and Eth., vol. 2, No. 1, 1904, pp. 1–27. New Mammalia from the Quaternary caves of California: Bull. Dept. Geology, Univ. California, vol. 4, 1905, pp. 145–161.

dactyla-Cervidæ, the typical American deer *Odocoileus* is abundant. Negatively we note the absence or disappearance of Perissodactyla-*Tapirus*, of Carnivora-Machærodontinæ; these absences may have been due to local conditions; the machærodonts are frequently associated with a Plains fauna, as in the California asphaltum deposits. The nonappearance of the genus *Cervus* as well as of Rodentia-Hystricomorpha is significant.

A large number of new types appear. Among primates the presence of *Homo* is indicated, in the opinion of certain anthropologists (Putnam), by supposed bone implements; others (Merriam[a]) regard this evidence as inconclusive. Among Carnivora-Ursidæ, remains of *Ursus* and *Arctotherium* are very numerous; among Felidæ, *Felis* (a species of large size), *Lynx;* among Canidæ, *Urocyon, Vulpes, Canis;* among Mustelidæ, *Taxidea, Mephitis, Spilogale, Putorius;* among Procyonidæ, *Bassariscus;* among Rodentia, 17 existing species; among Artiodactyla, (*a*) Dicotylidæ, *Platygonus* (a doubtful determination); among (*b*) Cervidæ, *Odocoileus;* among (*c*) Bovidæ, *Bison;* among (*d*) Rupricaprinæ, *Haploceras;* among (*e*) Ovinæ, *Euceratherium* [b] (related to *Ovibos*); among (*f*) Camelidæ, *Camelus;* among Edentata, *Megalonyx* (a forest and foothill edentate), 4 species; among Perissodactyla-Equidæ, *Equus*, 2 species; among Proboscidea, *Mastodon* (its first appearance, the species at present indeterminate), *Elephas primigenius* (? *E. columbi*).

Washtuckna Lake, Washington.[c]—Of about the same age are the deposits of Washtuckna Lake, Washington, a forest, mountain, and open-country fauna, imperfectly known. Among Carnivora-Mustelidæ, *Taxidea;* among Felidæ, *Felis concolor, F. canadensis;* among Edentata, *Mylodon;* among Perissodactyla-Equidæ, *Equus;* among Artiodactyla-Cervidæ, *Alces*, 2 species, *Odocoileus*, 1 species; among Camelidæ, *Camelus*, 3 species; among Rupricaprinæ, *Haploceros.*

Samwel cave, California.—In Samwel cave, Shasta County, Cal., is found (Furlong[d]) a fauna much more recent than that of the Potter Creek cave, including *Preptoceras* (with affinities to *Ovibos* and closer affinities to *Euceratherium*). Among Rodentia the Hystricomorpha appear; among Artiodactyla-Cervidæ, *Odocoileus;* among the absent or nonrecorded forms, Ursidæ, *Arctotherium.*

---

[a] Merriam, J. C., Recent cave exploration in California: Am. Anthropologist, April–June, 1906, p. 221.

[b] Sinclair, W. J., and Furlong, E. L., *Euceratherium*, a new ungulate from the Quaternary caves of California: Bull. Dept. Geology, Univ. California, vol. 3, 1904, pp. 411–418.

[c] Matthew, W. D., List of the Pleistocene fauna from Hay Springs, Nebraska: Bull. Am. Mus. Nat. Hist., vol. 21, 1902, pp. 321–322.

[d] Furlong, E. L., The exploration of Samwel cave: Am. Jour. Sci., 4th ser., vol. 22, Sept., 1906, pp. 235–247.

LATE PHASE OF THE MID-PLEISTOCENE.

The Conard fissure of Newton County, Ark.,[a] contains a typical forest fauna that lived in a region with open glades similar to the present landscape. It is very rich in individual specimens. Of the 37 genera and 51 species of mammals represented, 4 genera and 24 species are now extinct. Twenty genera and 6 species which occur in the Port Kennedy cave are also found here. Of the surviving species many are now distinctly northern or boreal types, such as *Microsorex, Mustela americana, Erethizon dorsatus, Cervus canadensis.* There are also 7 species of amphibians and reptiles and 7 species of birds.

The Proboscidea, Edentata, Tapiridæ, and Camelidæ of the earlier Pleistocene faunæ have all disappeared or are not represented. Only *Equus* and a machærodont (*Smilodontopsis*) survive. There is no evidence of *Homo.*

Among Carnivora, (1) Ursidæ (*Ursus*) are numerous; (2) among Felidæ-Felinæ, *Felis,* subgenus *Lynx;* among Machærodontinæ, *Smilodontopsis* (Brown), a surviving saber-tooth; (3) among Canidæ, *Canis, Vulpes,* and *Urocyon;* (4) among Mustelidæ, *Mephitis, Spilogale, Brachyprotoma* (an extinct skunk, also found in the Port Kennedy cave fauna), *Mustela,* and *Putorius;* (5) among Procyonidæ, *Procyon;* among Insectivora, *Blarina, Sorex, Microsorex, Scalops;* among Cheiroptera, *Vespertilio* and *Myotis;* among Rodentia, *Lepus, Microtus, Fiber, Neotoma, Reithrodontomys, Peromyscus, Castor, Geomys, Spermophilus, Tamias, Sciurus, Arctomys,* and the hystricomorph *Erethizon;* among Artiodactyla-Dicotylidæ, *Mylohyus;* among Cervidæ, *Odocoileus;* among Equidæ, *Equus* (represented by a single tooth); among Bovidæ?, the aberrant musk ox, *Symbos.*

CONCLUSION.

The conclusion is that North America promises to give us a nearly complete and unbroken history of the Tertiary in certain ancient regions, which are, after all, comparatively restricted. The middle and upper Eocene is approaching solution, but the lower and basal Eocene still require additional surveys. The chief remaining gap is now in the Pliocene stratigraphy, which calls for very exact geologic sectioning and most careful systematic or faunistic comparisons.

Materials are at hand for an establishment of the Pleistocene sequence, which will be of the greatest aid to geologists. Here especially the paleontologist must work with the greatest caution in the identification and description of species. It would be easy by careless methods to separate two depositions which are actually closely similar in age.

---

[a] Discovered in 1903 by Mr. Waldo Conard. The fauna was explored in 1903–4 and described by Barnum Brown in 1908: Mem. Am. Mus. Nat. Hist., vol. 9, 1908, pp. 157–208.

APPENDIX.

FAUNAL LISTS OF THE TERTIARY MAMMALIA OF THE WEST.

By William Diller Matthew.

BASAL EOCENE.

First phase—Puerco.	Second phase—Torrejon.
Polymastodon zone.	*Pantolambda* zone.
1. San Juan basin, New Mexico.	1. San Juan basin, New Mexico. 2. Fort Union formation (in part), Montana.

MULTITUBERCULATA.

Plagiaulacidæ.

	1.		1.	2.
Neoplagiaulax americanus Cope	×	Neoplagiaulax molestus Cope	×	
Catopsalis foliatus Cope	×	Ptilodus mediævus Cope	×	
Polymastodon taoensis Cope	×	Ptilodus trovessartianus Cope	×	
Polymastodon attenuatus Cope	×	Polymastodon fissidens Cope	?	
Polymastodon selenodus O. and E	×			

Bolodontidæ.

		Chirox plicatus Cope	×	

CREODONTA.

Miacidæ.

		Didymictis haydenianus Cope	×	

Arctocyonidæ.

		Clænodon corrugatus (Cope)	×	
(?)		Clænodon ferox (Cope)	×	
		? Clænodon protogonioides (Cope)	×	

Mesonychidæ.

		Dissacus navajovius Cope	×	
		Dissacus saurognathus Wortman	×	

Triisodontidæ.

Triisodon quivirensis Cope	×	Sarcothraustes antiquus Cope	×	
Triisodon heilprinianus Cope	×	Goniacodon levisanus Cope	×	
Triisodon gaudrianus (Cope)	×	Microclænodon assurgens Cope	×	

Oxyclænidæ.[a]

Oxyclænus cuspidatus Cope	×	Chriacus pelvidens (Cope)	×	
Oxyclænus simplex (Cope)	×	Chriacus baldwini Cope	×	
Loxolophus hyattianus (Cope)	×	Chriacus truncatus Cope	×	
Loxolophus priscus (Cope)	×	Chriacus schlosserianus Cope	×	
Loxolophus attenuatus O. and E	×	Tricentes subtrigonus (Cope)	×	
Carcinodon filholianus (Cope)	×	Tricentes crassicollidens Cope	×	
Paradoxodon rutimeyeranus (Cope)	×	Deltatherium fundaminis Cope	×	

[a] Part or all of this family may be referable to the Insectivora, according to Wortman.

BASAL EOCENE—Continued.

INSECTIVORA.

?Hyopsodontidæ.

	1.		1.	2.
Mioclænus turgidunculus Cope	×	Mioclænus turgidus Cope	×	
		Mioclænus lemuroides Matthew	×	
		Mioclænus acolytus Cope	×	×
		Mioclænus lydekkerianus Cope	×	
		Mioclænus inæquidens (Cope)	×	
		?Protoselene opisthacus (Cope)	×	

Incertæ sedis.

	1.		1.	2.
Oxyacodon apiculatus O. and E	×			
Oxyacodon agapetillus (Cope)	×			

Pantolestidæ.

	1.		1.	2.
		Pentacodon inversus Cope	×	

Mixodectidæ.[a]

	1.		1.	2.
		Mixodectes pungens Cope	×	
		Mixodectes crassiusculus (Cope)	×	
		Indrodon malaris Cope	×	

TÆNIODONTA.

Stylinodontidæ.

	1.		1.	2.
Wortmania otariidens Cope	×	Psittacotherium multifragum Cope	×	

Conoryctidæ.[b]

	1.		1.	2.
Onychodectes tisonensis Cope	×	Conoryctes comma Cope	×	
Onychodectes rarus O. and E	×			

CONDYLARTHRA.

Phenacodontidæ.

	1.		1.	2.
?Protogonodon pentacus Cope	×	Tetraclænodon puercensis (Cope)	×	×
?Protogonodon stenognathus Matthew	×	Tetraclænodon minor (Matthew)	×	

AMBLYPODA.

Periptychidæ.[c]

	1.		1.	2.
Periptychus coarctatus Cope	×	Periptychus carinidens Cope	×	
Ectoconus ditrigonus (Cope)	×	Periptychus rhabdodon (Cope)	×	
Conacodon entoconus (Cope)	×	Haploconus lineatus Cope	×	
Conacodon cophater (Cope)	×	Haploconus corniculatus Cope	×	
Anisonchus gillianus Cope	×	Anisonchus sectorius Cope	×	
Hemithlæus kowalevskianus Cope	×			

Pantolambdidæ.

	1.		1.	2.
		Pantolambda bathmodon Cope	×	
		Pantolambda cavirictus Cope	×	×

LOWER EOCENE.

First phase—Wasatch.

Coryphodon zone.

1. Typical Wasatch, Evanston, Wyoming.
2. Black Buttes, Washakie basin, Wyoming.
3. Bighorn Valley, Wyoming.
4. San Juan basin, New Mexico.

Second phase—Wind River.

Lambdotherium and *Bathyopsis* zones.

1. Wind River basin, Wyoming.
2. Lower Huerfano, Colorado.

PRIMATES.

Notharctidæ.

	1.	2.	3.	4.		1.	2.
Pelycodus jarrovii Cope				×	Pelycodus sp	×	
Pelycodus tutus Cope			×	×	Notharctus nunienus Cope	×	
Pelycodus frugivorus Cope			×	×	Notharctus venticolus Osborn	×	
					Notharctus palmeri Loomis	×	
					Notharctus cingulatus Loomis	×	

[a] Order Proglires of uncertain relationship, according to Osborn.
[b] ?Insectivora.
[c] Auct. Osborn; Condylarthra according to Matthew.

LOWER EOCENE—Continued.

PRIMATES—Continued.

ANAPTOMORPHIDÆ.

	1.	2.	3.	4.		1.	2.
Anaptomorphus homunculus Cope			×		Anaptomorphus spierianus Cope	×	
Anaptomorphus minimus Loomis			×		Anaptomorphus abboti Loomis	×	
					? Omomys ("Notharctus") minutus Loomis	×	
					Anaptomorphid gen. indesc	×	
MICROSYOPIDÆ.[a]							
Cynodontomys latidens Cope			×		Cynodontomys sp	×	
Cynodontomys angulatus (Cope)				×	Microsyops scottianus Cope	×	

CARNIVORA (CREODONTA).

	1.	2.	3.	4.		1.	2.
MIACIDÆ.							
Didymictis protenus (Cope)			×	×	Didymictis altidens Cope	×	×
Didymictis leptomylus Cope			×	×	Didymictis leptomylus Cope	×	
Viverravus cf. dawkinsianus (Cope)			×		Viverravus dawkinsianus (Cope)	×	×
Miacis sp			×		Miacis sp	×	
Uintacyon massetericus (Cope)			×		Oödectes sp	×	
Vassacyon promicrodon (W. and M.)[b]			×		Vulpavus canavus (Cope)	×	
Vulpavus cf. brevirostris (Cope)			×		Vulpavus brevirostris (Cope)	×	
Vulpavus sp				×			
? ARCTOCYONIDÆ.							
Anacodon ursidens Cope			×				
PALÆONICTIDÆ (=AMBLOCTONIDÆ).							
Palæonictis occidentalis Osborn			×				
Ambloctonus sinosus Cope				×			
OXYÆNIDÆ.							
Oxyæna lupina Cope			×	×	Oxyæna huerfanensis Osborn		×
Oxyæna forcipata Cope			×	×	Oxyæna sp	×	
Oxyæna morsitans Cope				×	Patriofelis tigrinus (Cope)	×	
					Limnocyon sp	×	
HYÆNODONTIDÆ.							
Sinopa viverrina (Cope)			?	×	Sinopa sp	×	
Sinopa strenua (Cope)			×	×	Tritemnodon whitiæ (Cope)	×	
Sinopa multicuspis (Cope)			?	×			
Sinopa hians (Cope)			×	×			
Sinopa opisthotoma Matthew			×				
MESONYCHIDÆ.							
Pachyæna ossifraga Cope			×	×	Pachyæna cf. gigantea[c]	×	
Pachyæna gigantea Osborn			×		Hapalodectes sp. indesc	×	
Pachyæna intermedia Wortman			×				
Hapalodectes leptognathus (Osborn)[d]			×				

INSECTIVORA.

	1.	2.	3.	4.		1.	2.
PANTOLESTIDÆ.							
Palæosinopa veterrima Matthew			×		Palæosinopa didelphoides (Cope)	×	
LEPTICTIDÆ.							
Palæictops cf. bicuspis			×		Palæictops bicuspis (Cope)	×	
HYOPSODONTIDÆ.							
Hyopsodus miticulus (Cope)				×	Hyopsodus wortmani Osborn	×	
Hyopsodus lemoinianus Cope			×		Hyopsodus browni Loomis	×	
Hyopsodus powellianus Cope			×		Hyopsodus jacksoni Loomis	×	
Hyopsodus laticuneus (Cope)			×		? Hyopsodus minor Loomis	×	
Hyopsodus simplex Loomis			×		Hyopsodus cf. powellianus		×
					Hyopsodus sp		×
INCERTÆ SEDIS.							
Diacodon alticuspis Cope				×	"Peratherium" comstocki Cope	×	
Diacodon celatus Cope				×			
Didelphodus absarokæ Cope[e]			×				

[a] ? = Mixodectidæ (Insectivora).
[b] Gen. nov. Type, *Uintacyon promicrodon* W. and M., 1899. Differs from *Uintacyon* in broad basin-heel of lower carnassial and other characters.
[c] Auct. F. B. Loomis in lit.
[d] Gen. nov. Type, *Dissacus leptognathus*, Osborn and Wortman, Bull. Am. Mus. Nat. Hist., vol. 4, p. 112, fig. 10.
[e] Probably Insectivore, auct. J. L. Wortman.

LOWER EOCENE—Continued.

TILLODONTIA.

? ANCHIPPODONTIDÆ.

	1.	2.	3.	4.
Esthonyx burmeisteri Cope			×	×
Esthonyx acer Cope				×
Esthonyx bisulcatus Cope				×
Esthonyx spatularius Cope				×

	1.	2.
Esthonyx acutidens Cope	×	
Esthonyx spatularius Cope	×	

RODENTIA.

ISCHYROMYIDÆ.

	1.	2.	3.	4.
Paramys primævus Loomis			×	
Paramys quadratus Loomis			×	
Paramys atwateri Loomis			×	
? Sciuravus buccatus (Cope)				×

	1.	2.
Paramys bicuspis Loomis	×	
Paramys copei Loomis	×	
Paramys major Loomis	×	
Paramys excavatus Loomis	×	
Sciuravus depressus Loomis	×	

TÆNIODONTA.

STYLINODONTIDÆ.

	1.	2.	3.	4.
Calamodon simplex Cope			×	×
Calamodon arcamœnus Cope				×
Calamodon novomehicanus Cope				×
Ectoganus gliriformis Cope				×
Dryptodon crassus Marsh				

	1.	2.
Stylinodon cylindrifer (Cope)	×	

CONDYLARTHRA.

PHENACODONTIDÆ.

	1.	2.	3.	4.
Phenacodus primævus Cope	×		×	×
Phenacodus nunienus Cope			×	
Phenacodus hemiconus Cope			×	
Phenacodus astutus (Cope)[a]			×	×
Phenacodus flagrans (Cope)				×
Phenacodus brachypternus Cope			×	
Phenacodus macropternus Cope			×	
?Phenacodus sulcatus Cope[b]				×
Eohyus distans Marsh				
Eohyus robustus Marsh				
Ectocion osbornianus Cope			×	

	1.	2.
Phenacodus wortmani Cope	×	
Phenacodus sp	×	
Ectocion cf. osbornianus	×	

MENISCOTHERIIDÆ.

	1.	2.	3.	4.
Meniscotherium terrærubræ Cope				×
Meniscotherium chamense Cope				×
Meniscotherium tapiacitis Cope				×

AMBLYPODA.

CORYPHODONTIDÆ.

	1.	2.	3.	4.
Coryphodon radians Cope	×			
Coryphodon testis Cope			×	
Coryphodon lobatus Cope			×	×
Coryphodon elephantopus Cope			×	×
Coryphodon hamatus Marsh	×		×	
Coryphodon latidens Cope				×
Coryphodon curvicristis Cope			×	
Coryphodon armatus Cope		×		

	1.	2.
Coryphodon ventanus Osborn	×	×
Coryphodon wortmani Osborn	×	
?Coryphodon singularis Osborn	×	

EOBASILEIDÆ (=UINTATHERIIDÆ).

	1.	2.
Bathyopsis fissidens Cope	×	

PERISSODACTYLA.

LOPHIODONTIDÆ.

	1.	2.	3.	4.
Heptodon posticus Cope			×	
Heptodon singularis (Cope)[b]				×

	1.	2.
Heptodon calciculus Cope	×	
Heptodon ventorum Cope	×	

TAPIRIDÆ.

	1.	2.	3.	4.
Systemodon tapirinus (Cope)				×
Systemodon protapirinus Wortman			×	
Systemodon primævus Wortman			×	
Systemodon semihians Cope			×	

[a] *P. wortmani* Cope in part.

[b] Incertæ sedis.

LOWER EOCENE—Continued.

PERISSODACTYLA—Continued.

Equidæ.

	1.	2.	3.	4.
Eohippus pernix Marsh		×		
Eohippus validus Marsh				×
Eohippus vasacciensis (Cope)	×			
Eohippus index (Cope)	×			
Eohippus angustidens (Cope)				×
Eohippus cuspidatus (Cope)				×
Eohippus cristatus (Wortman)			×	
Eohippus cristonensis (Cope)			×	×
Eohippus montanus Wortman			×	
Eohippus borealis Granger			×	
Eohippus resartus Granger			×	

	1.	2.
Eohippus venticolus (Cope)	×	?
Eohippus craspedotus (Cope)	×	

Titanotheriidæ (=Brontotheriidæ).

	1.	2.
Lambdotherium popoagicum Cope	×	×
Eotitanops borealis (Cope)	×	
Eotitanops brownianus (Cope)	×	

ARTIODACTYLA.

Trigonolestidæ (=? Dichobunidæ).

	1.	2.	3.	4.
Trigonolestes brachystomus (Cope)			×	
Trigonolestes chacensis (Cope)			?	×
Trigonolestes nuptus (Cope)			×	
Trigonolestes metsiacus (Cope)			×	
Helohyus etsagicus (Cope)			×	

	1.	2.
Trigonolestes secans Cope	×	×

? Achænodontidæ.

	1.	2.	3.	4.
Parahyus vagus Marsh		×		
Parahyus aberrans Marsh		×		

MIDDLE EOCENE.

First phase—Bridger (lower part).

Orohippus zone.

1. Lower Bridger (horizon B), Wyoming.
2. Upper Huerfano, Colorado.

Second phase—Bridger (upper part).

Uintatherium zone.

1. Upper Bridger (horizons C and D), Wyoming.
2. Washakie Basin, Wyoming.

PRIMATES.

Notharctidæ.

	1.	2.
Pelycodus sp	×	
Notharctus tenebrosus Leidy	×	
Notharctus rostratus (Cope)	×	
Notharctus affinis (Marsh)	×	
Notharctus anceps (Marsh)	×	

	1.	2.
Notharctus tyrannus (Marsh)	?	
Telmatolestes crassus Marsh	×	
Notharctus aut Telmatolestes sp. div	×	×

Anaptomorphidæ.

	1.	2.
Omomys carteri Leidy	×	
Omomys pucillus (Marsh)	×	
Omomys ameghini Wortman	×	
Euryacodon lepidus Marsh	×	
Anaptomorphus æmulus Cope	×	
? Anaptomorphus sp	×	
? Smilodectes gracilis (Marsh) [a]		

	1.	2.
Hemiacodon gracilis Marsh	×	
Hemiacodon pygmæus Wortman	×	
Washakius insignis Leidy	×	
Washakius sp	×	

Microsyopidæ.[b]

	1.	2.
Microsyops elegans (Marsh)	×	
Microsyops typus (Marsh)	×	
Microsyops sp	×	×

	1.	2.
Microsyops annectens (Marsh)	×	
Microsyops schlosseri Wortman	?	
Microsyops sp	×	

[a] Incertæ sedis.

[b] ? = Mixodectidæ (Insectivora).

MIDDLE EOCENE—Continued.

CARNIVORA (CREODONTA).

MIACIDÆ.

	1.	2.		1.	2.
Viverravus gracilis Marsh	×		Viverravus gracilis Marsh	×	
Viverravus minutus Wortman	×		Viverravus minutus Wortman	×	
Viverravus sp. indesc	×		Miacis sylvestris (Marsh)	×	
Miacis parvivorus Cope	×		Miacis hargeri (Wortman)	×	
Uintacyon vorax Leidy	×		Miacis washakius (Wortman)		×
Uintacyon edax Leidy	?		Miacis sp. indesc		×
? Uintacyon bathygnathus (Scott)	?		Uintacyon vorax Leidy	?	
Oödectes herpestoides Wortman	×		Uintacyon sp. indesc	×	
Oödectes sp. indesc	×		Uintacyon sp. indesc	×	
Vulpavus palustris Marsh	×		? Oödectes pugnax (W. & M.)		×
Vulpavus sp. indesc	×		Gen. et sp. indesc	×	
Vulpavus sp. indesc	×				

OXYÆNIDÆ.

	1.	2.		1.	2.
Patriofelis ulta Leidy	×		Patriofelis ferox (Marsh)		
? Patriofelis coloradensis [a] sp. nov		×	Limnocyon sp. indesc		×
Limnocyon verus Marsh	×		Limnocyon ? verus Marsh	×	
Thinocyon velox Marsh	×		Thinocyon medius Wortman	×	
Thinocyon sp. indesc	×		Thinocyon sp. indesc		×
Gen. et sp. indesc	×				

HYÆNODONTIDÆ.

	1.	2.		1.	2.
Sinopa rapax Leidy	×		Sinopa rapax, var. indesc		×
Sinopa pungens (Cope)	×		Sinopa major Wortman	×	
Sinopa major Wortman	?		Sinopa minor Wortman	?	
Sinopa minor Wortman	×				
Sinopa grangeri Matthew	×				
Tritemnodon agilis Marsh	×				

MESONYCHIDÆ.

	1.	2.		1.	2.
Mesonyx obtusidens Cope	×		Synoplotherium lanius Cope [b]	×	×
Harpagolestes macrocephalus Wortman	×				

INSECTIVORA.

APATEMYIDÆ.

	1.	2.		1.	2.
			Apatemys bellus Marsh	×	
			Apatemys bellulus Marsh	×	
			Gen. et sp. indesc	×	
			Gen. et sp. indesc	×	
			Gen. et sp. indesc	×	

? TALPIDÆ.

	1.	2.		1.	2.
Nyctilestes serotinus Marsh	×		Talpavus nitidus Marsh	×	
Gen. et sp. indesc	×		Nyctitherium velox Marsh	×	
Gen. et sp. indesc	×		Nyctitherium priscus Marsh	×	
Entomacodon angustidens Marsh	×		Gen. et sp. indesc	×	
			Gen. et sp. indesc	×	
			Gen. et sp. indesc	×	
			Gen. et sp. indesc	×	
			Entomacodon minutus Marsh	×	

? CENTETIDÆ.

	1.	2.		1.	2.
			Centetodon pulcher Marsh	×	
			Centetodon altidens Marsh	×	
			Centracodon delicatus Marsh	×	

? LEPTICTIDÆ.

	1.	2.		1.	2.
			Antiacodon venustus Marsh	×	
			Passalacodon littoralis Marsh	×	
			Anisacodon elegans Marsh	×	
			Gen. et sp. indesc	×	

HYOPSODONTIDÆ.

	1.	2.		1.	2.
Hyopsodus paulus Leidy	×		Hyopsodus sp. indesc	×	×
Hyopsodus minusculus Leidy	×		Hyopsodus sp. indesc	×	
			Hyopsodus marshi Osborn	×	

PANTOLESTIDÆ.

	1.	2.		1.	2.
Pantolestes longicaudus Cope	×		Pantolestes sp. indesc	×	
Pantolestes sp. indesc	×		Pantolestes sp. indesc	×	
			Pantolestes cf. longicaudus	×	

[a] "*P. ulta* Leidy," Osborn, Bull. Am. Mus. Nat. Hist., 1897, p. 256; idem, 1900, p. 278, fig. 8. Not *P. ulta* of Leidy.

[b] Including *Dromocyon vorax* Marsh.

MIDDLE EOCENE—Continued.

TILLODONTIA.

ANCHIPPODONTIDÆ.

	1.	2.		1.	2.
Trogosus castoridens Leidy[a]	×		Tillotherium fodiens Marsh	×	
Trogosus minor Marsh	×		Tillotherium hyracoides Marsh		
? Tillotherium sp		×	Tillotherium latidens Marsh		

RODENTIA.

ISCHYROMYIDÆ.

	1.	2.		1.	2.
Paramys delicatus Leidy	×		Paramys leptodus (Cope)		×
Paramys delicatior Leidy	×		Paramys sp. div	×	×
Paramys delicatissimus Leidy	×		Pseudotomus sp. div	×	×
Paramys sp. div	×	×	Sciuravus sp. div	×	
Pseudotomus hians Cope	×		Colonomys celer Marsh	×	
Pseudotomus robustus (Marsh)	×		Taxymys lucaris Marsh	×	
Pseudotomus superbus (O., S., and S.)	×		Tillomys senex Marsh	×	
Pseudotomus sp. div	×				
Sciuravus nitidus Marsh	×				
Sciuravus undans Marsh	×				
Sciuravus parvidens Marsh	×				
Sciuravus minimus (Leidy)	×				
Sciuravus sp. div	×				
Tillomys parvus Marsh	×				

TÆNIODONTA.

STYLINODONTIDÆ.

	1.	2.
Stylinodon mirus Marsh	?	

EDENTATA.

METACHEIROMYIDÆ.

	1.	2.		1.	2.
Metacheiromys marshi Wortman	×		Metacheiromys sp	×	
Metacheiromys dasypus Osborn	×				
Metacheiromys tatusia Osborn	×				

AMBLYPODA.

EOBASILEIDÆ (=UINTATHERIIDÆ).

	1.	2.		1.	2.
? Uintatherium sp		×	Uintatherium robustum Leidy	×	
			Uintatherium latifrons Marsh	×	
			Uintatherium leidyanum O., S., and S.	×	
			Uintatherium spierianum (S. and O.)[b]		×
			U. (Dinoceras) mirabile Marsh	×	
			U. (Dinoceras) agreste Marsh	×	
			U. (Dinoceras) laticeps Marsh	×	
			U. (Dinoceras) lucare Marsh	×	
			U. (Tinoceras) anceps Marsh	×	
			U. (Tinoceras) crassifrons Marsh	×	
			U. (Tinoceras) hians Marsh	×	
			U. (Tinoceras) grandis Marsh		×
			U. (Tinoceras) ingens Marsh		×
			U. (Tinoceras) longiceps Marsh		×
			U. (Tinoceras) pugnax Marsh		×
			U. (Tinoceras) stenops Marsh		×
			U. (Tinoceras) vagans Marsh		×
			U. (Tinoceras) affinis Marsh		×
			U. (Tinoceras) annectens Marsh		×

PERISSODACTYLA.

HYRACODONTIDÆ.

	1.	2.		1.	2.
Hyrachyus agrarius Leidy	×		Hyrachyus eximius Leidy	×	
Hyrachyus sp. div	×	×	Hyrachyus intermedius O., S., and S.	×	
? Hyrachyus bairdianus (Marsh)	?		Hyrachyus crassidens O., S., and S	×	
Hyrachyus paradoxus O., S., and S	?		Hyrachyus princeps Marsh	×	
Colonoceras agrestis Marsh	?		Hyrachyus imperialis O., S., and S.	×	
			Hyrachyus sp. div	×	×
			Triplopus cubitalis Cope		×
			"Triplopus" amarorum Cope		×

[a] Identified by Leidy with *Anchippodus vetulus* from a Tertiary formation in New Jersey. The type of *A. vetulus* is indeterminate generically, and it is not certain that it belongs to the same family as *Trogosus* and *Tillotherium*. I retain *Trogosus* as distinct in order to avoid a misleading correlation.

[b] This species may belong to the upper "Washakie" level, and to the genus *Eobasileus*.

MIDDLE EOCENE—Continued.

PERISSODACTYLA—Continued.

LOPHIODONTIDÆ.

	1.	2.		1.	2.
Helaletes boöps Marsh	×		Helaletes sp. div	×	×
Helaletes nanus (Leidy)	×		Desmatotherium guyoti Scott		×
Helaletes sp. div	×		Dilophodon minusculus Scott		×

TAPIRIDÆ.

	1.	2.		1.	2.
? Isectolophus modestus (Leidy)	×		Isectolophus latidens (S. and O.)	×	

EQUIDÆ.

	1.	2.		1.	2.
Orohippus pumilus (Marsh)	×		Orohippus sylvaticus (Leidy)	×	
Orohippus ballardi (Marsh)	×		Orohippus agilis Marsh	×	
Orohippus procyoninus (Cope)	×		Orohippus uintanus (Marsh)	×	
Orohippus major Marsh	×				
Orohippus cinctus (Cope)	×				
Orohippus osbornianus (Cope)	×				

TITANOTHERIIDÆ (=BRONTOTHERIIDÆ).[a]

	1.	2.		1.	2.
Palæosyops paludosus Leidy	×		Palæosyops humilis Leidy	×	
Palæosyops major Leidy	×		Palæosyops robustus Marsh	×	
Palæosyops fontinalis Cope	×		Limnohyops diaconus Cope	×	
Limnohyops laticeps Marsh	×		Telmatherium validum Marsh	×	
Palæosyopinæ sp. div	×		Telmatherium cultridens S. and O	×	
			Telmatherium hyognathum S. and O		
			Telmatherium megarhinum Earle	×	×
			Telmatherium vallidens (Cope)		
			Manteoceras manteoceras (Osborn)	×	×
			Palæosyopinæ sp. div	×	×

ARTIODACTYLA.

HOMACODONTIDÆ (=DICHOBUNIDÆ).[b]

	1.	2.		1.	2.
Homacodon sp. aff. vagans	×		Homacodon vagans Marsh	×	
Microsus cuspidatus Leidy	×		? Stenacodon rarus Marsh	×	
Sarcolemur pygmæus (Cope)	×		Helohyus lentus (Marsh)	×	
Sarcolemur furcatus Cope	×		Helohyus validus (Marsh)	×	
Nanomeryx caudatus Marsh	?		Helohyus sp. div	×	
Helohyus plicodon Marsh	×		? Ithygrammodon cameloides O., S., and S.	?	
Helohyus sp. div	×				

UPPER EOCENE.

FIRST PHASE.

Eobasileus zone.

1. Washakie Basin, Wyoming (upper beds).
2. Uinta Basin, Utah (horizons A and B).
3. ? Sage Creek, Montana.
4. ? Uppermost Bridger (horizon E), Wyoming.

SECOND PHASE—TRUE UINTA.

Diplacodon zone.

1. Uinta Basin, Utah (horizon C).

PRIMATES.

NOTHARCTIDÆ.

	1.	2.	3.	4.		1.
Notharctus uintensis (Osborn)		×		?		

CARNIVORA (CREODONTA).

MIACIDÆ.

	1.	2.	3.	4.		1.
Miacis uintensis Osborn		?			Miacis vulpinus S. and O	×
					Miacis uintensis Osborn	×
					? Uintacyon scotti (W. and M.)	?

OXYÆNIDÆ.

	1.	2.	3.	4.		1.
Oxyænodon dysodus Matthew		×			Oxyænodon dysclerus Hay	×
Thinocyon sp. indesc	×				Limnocyon sp. indesc	×

MESONYCHIDÆ.

	1.	2.	3.	4.		1.
Harpagolestes uintensis (S. and O.)		×			Harpagolestes uintensis (S. and O.)	?
Harpagolestes sp. indesc	×					
Mesonyx sp		×				

[a] The Eocene titanotheres will be revised and the list of genera and species considerably extended in Professor Osborn's forthcoming monograph on the family.

[b] See Stehlin, Säugethiere des schweizerischen Eocäns, IV. Th., Abhandl. Schw. pal. Ges., vol. 23, 1906, p. 669, for inclusion of *Homacodon* and related genera in the Dichobunidæ. The reference of *Microsus* and *Sarcolemur* to this group is based on comparison with *Homacodon*.

UPPER EOCENE—Continued.

CARNIVORA (FISSIPEDIA).

CANIDÆ.

	1.
Procynodictis vulpiceps W. and M.	×

INSECTIVORA.

HYOPSODONTIDÆ.

	1.
Hyopsodus gracilis Marsh	×
Hyopsodus uintensis Osborn	×

RODENTIA.

ISCHYROMYIDÆ.

	1.	2.	3.	4.
Paramys uintensis Osborn		×		
Paramys sp. div	×	×		

	1.
Paramys sciuroides S. and O.	×
Paramys sp. div	×
Pseudotomus sp. div	×

? GEOMYIDÆ.

	1.
Protoptychus hatcheri Scott	×

AMBLYPODA.

EOBASILEIDÆ.

	1.	2.	3.	4.
Eobasileus cornutus Cope	×			
Eobasileus furcatus Cope	?			
Eobasileus pressicornis Cope	?			
Eobasileus galeatus (Cope)	?			
Eobasileus sp. div	×	×		

PERISSODACTYLA.

HYRACODONTIDÆ.

	1.	2.	3.	4.
Hyrachyus priscus Douglass			×	
Hyrachyus sp. div	×	×		

	1.
Triplopus obliquidens (S. and O.)	×

AMYNODONTIDÆ.

	1.	2.	3.	4.
Amynodon antiquus (S. and O.)	×			
Amynodon sp	×	×		
"Metamynodon" sp. (=? Amynodon)			×	

	1.
Amynodon advenus Marsh	×
Amynodon intermedius S. and O.	×

LOPHIODONTIDÆ.

	1.	2.	3.	4.
"Heptodon"? sp. (=? Helaletes)			×	

TAPIRIDÆ.

	1.
Isectolophus annectens (S. and O.)	×

EQUIDÆ.

	1.
Epihippus uintensis Marsh	×
Epihippus gracilis Marsh	×
Epihippus parvus Granger	×

TITANOTHERIIDÆ (=BRONTOTHERIIDÆ).[a]

	1.	2.	3.	4.
Dolichorhinus cornutus (Osborn)		×		
Dolichorhinus sp	×			
Telmatherium diploconum Osborn		×		
Telmatherium sp. div	×	×		?
Manteoceras sp. div	×	×		

	1.
Diplacodon elatus Marsh	×
Diplacodon emarginatus Hatcher	×
Diplacodon sp	×
Telmatherium sp. div	×
Manteoceras ultimus (Osborn)	×
Manteoceras sp. div	×

ARTIODACTYLA.

ACHÆNODONTIDÆ.

	1.	2.	3.	4.
Achænodon insolens Cope	?			
Achænodon robustus Osborn	?			
Achænodon uintensis (Osborn)		×		
Achænodon sp	×			

? DICHOBUNIDÆ.[b]

	1.
Bunomeryx montanus Wortman	×
Bunomeryx elegans Wortman	×

[a] See footnote [a] on p. 98. [b] Auct. Stehlin. See footnote [b] on p. 98.

UPPER EOCENE—Continued.

ARTIODACTYLA—Continued.

CAMELIDÆ OR HYPERTRAGULIDÆ.

	1.	2.	3.	4.
Leptotragulus proavus S. and O.		×		
?Leptotragulus sp	×			
Leptoreodon ? marshi Wortman.	×			

	1.
Leptotragulus proavus S. and O.	×
Leptotragulus lævis (Marsh)	×
Leptotragulus sulcatus (Marsh)	×
Protylopus petersoni Wortman	×
Camelomeryx longiceps Scott	×
Oromeryx plicatus Marsh	×

OREODONTIDÆ.

	1.
Protoreodon parvus S. and O.	×
Protoreodon pumilus (Marsh)	×
Protoreodon paradoxicus (Scott)	×
Protoreodon minor Scott	×
Protagriochœrus annectens Scott	×
Hyomeryx breviceps Marsh	×

Range of Eocene genera.

[The figures show the number of known species in each genus. Crosses indicate that the presence of the genus is recorded but no species have been described.]

	Basal.		Lower.		Middle.		Upper.	
	First phase.	Second phase.	First phase.	Second phase.	First phase.	Second phase.	First phase.	Second phase.
MULTITUBERCULATA.								
Plagiaulacidæ								
Polymastodon	3							
Catopsalis	1							
Neoplagiaulax	1	1						
Ptilodus		2						
Bolodontidæ								
Chirox		1						
PRIMATES.								
Notharctidæ								
Pelycodus			3	×	×			
Notharctus				4	3	1	1	
Telmalestes						1		
Anaptomorphidæ								
Anaptomorphus			?2	2	1			
Omomys				1	2			
Hemiacodon						2		
Euryacodon					1			
Washakius						1		
? Smilodectes					1			
?Microsyopidæ								
Cynodontomys			2	1				
Microsyops				1	2	2		
CARNIVORA (CREODONTA).								
Miacidæ								
Didymictis		1	2	2				
Viverravus			×	1	3	2		
Miacis			×	×	1	4	?	2
Uintacyon			1		1	4		?1
Vassacyon			1					
Oödectes				×	2	1		
Vulpavus			×	2	3			
Gen. indesc						1		
Arctocyonidæ								
Clænodon		3						
? Anacodon			1					
Palæonictidæ (=Ambloctonidæ)								
Ambloctonus			1					
Palæonictis			1					
Oxyænidæ								
Oxyæna			3	1				
Patriofelis				1	2	1		
Limnocyon					1		×	
Thinocyon				×	2	2		
Oxyænodon							1	1
Gen. indesc					1			

Range of Eocene genera—Continued.

	Basal.		Lower.		Middle.		Upper.	
	First phase.	Second phase.	First phase.	Second phase.	First phase.	Second phase.	First phase.	Second phase.
CARNIVORA (CREODONTA)—Cont'd.								
Hyænodontidæ (Proviverrinæ)								
Sinopa			5	1	4	3		
Tritemnodon					1			
Mesonychidæ								
Dissacus		2						
Pachyæna			3	1				
Mesonyx					1		×	
Synoplotherium						1		
Harpagolestes					1		2	?
Hapalodectes			1	1				
Triisodontidæ								
Triisodon	3							
Sarcothraustes		1						
Goniacodon		1						
Microclænodon		1						
Oxyclænidæ								
Oxyclænus	2							
Protochriacus=Loxolophus	3							
Carcinodon	1							
Paradoxodon	1							
Chriacus		4						
Tricentes		2						
Deltatherium		1						
INSECTIVORA.								
Pantolestidæ								
Pentacodon		1						
Palæosinopa			1	1				
Pantolestes					2	2		
Hyopsodontidæ								
Mioclænus	1	4						
?Protoselene		1						
Hyopsodus			5	4	2	3		2
Leptictidæ								
Palæictops			×	1				
Antiacodon					1			
Passalacodon					1			
Anisacodon					1			
Gen. indesc					1			
Apatemyidæ								
Apatemys						2		
Gen. indesc						2		
Gen. indesc						1		
? Talpidæ								
Talpavus						1		
Nyctitherium						2		
Nyctilestes					1			
Gen. indesc					1			
Gen. indesc					1			
Gen. indesc						3		
Gen. indesc						1		
Entomacodon					1	1		
? Centetidæ								
Centetodon						2		
Centracodon						1		
Mixodectidæ								
Mixodectes		2						
Indrodon		1						
Olbodotes		1						
Incertæ sedis								
Oxyacodon	2							
Diacodon			2					
Didelphodus			1					
TILLODONTIA.								
?Anchippodontidæ								
Esthonyx			4	2				
Trogosus					2			
Tillotherium					?	? 3		
RODENTIA.								
Ischyromyidæ								
Paramys			3	4	3	1	1	1
Pseudotomus					3	×		×
Sciuravus			1	1	4			
Colonomys						1		
Taxymys						1		
Tillomys					1	1		
?Geomyidæ								
Protoptychus								1

Range of Eocene genera—Continued.

	Basal.		Lower.		Middle.		Upper.	
	First phase.	Second phase.	First phase.	Second phase.	First phase.	Second phase.	First phase.	Second phase.
TÆNIODONTA.								
Stylinodontidæ	—	—	—	—	—			
Wortmania	1							
Psittacotherium		3						
Calamodon (incl. Dryptodon)			4					
Ectoganus			1					
Stylinodon				1	? 1			
Conoryctidæ	—	—						
Onychodectes	2							
Conoryctes		1						
EDENTATA.								
Metacheiromyidæ:								
Metacheiromys					3			
AMBLYPODA.								
Periptychidæ	—	—						
Periptychus	1	1						
Ectoconus	1							
Conacodon	2							
Hemithlæus	1							
Haploconus		2						
Anisonchus	1	1						
Pantolambdidæ		—						
Pantolambda		2						
Coryphodontidæ			—	—				
Coryphodon			8	3				
Eobasileidæ				—	—	—	—	
Bathyopsis				1				
Uintatherium [a]					×	19		
Eobasileus							4	
CONDYLARTHRA.								
Phenacodontidæ	—	—	—	—				
Protogonodon	2							
Euprotogonia (=Tetraclænodon)		2						
Phenacodus			10	2				
Ectocion			1	1				
Meniscotheriidæ			—					
Meniscotherium [b]			3					
PERISSODACTYLA.								
Hyracodontidæ					—	—	—	—
Hyrachyus					1+	5+	1	
Colonoceras						? 1		
Triplopus						2		1
Amynodontidæ							—	—
Amynodon							1	2
Lophiodontidæ			—	—	—	—	—	—
Heptodon			2	2				
Helaletes [c]					2	1	×	
Desmatotherium						1		
Tapiridæ			—	—	—	—	—	—
Systemodon			4					
Isectolophus						1		1
Equidæ			—	—	—	—	—	—
Eohippus [d]			10	2+				
Orohippus [e]					6	3		
Epihippus							×	2
Titanotheriidæ				—	—	—	—	—
Lambdotherium				1				
Eotitanops				1				
Palæosyops					3	2		
Limnohyops					1	3		
Telmatherium						5	1	
Manteoceras						1	×	1
Dolichorhinus							2	
Diplacodon								2

[a] Including *Dinoceras* and *Tinoceras*.
[b] Including *Hyracops*.
[c] Including *Dilophodon*.
[d] Including *Protorohippus*.
[e] Including *Orotherium, Helohippus, Oligotomus*, and *Helotherium*.

Range of Eocene genera—Continued.

	Basal.		Lower.		Middle.		Upper.	
	First phase.	Second phase.	First phase.	Second phase.	First phase.	Second phase.	First phase.	Second phase.
ARTIODACTYLA.								
Achænodontidæ			—				—	
? Parahyus			2					
Achænodon							3	
Dichobunidæ			—	—	—	—	—	—
? Trigonolestes			4	1				
Homacodon					×	1		
Microsus					1			
Sarcolemur					2			
Nanomeryx					? 1			
? Stenacodon						1		
Helohyus			?		1	2		
? Ithygrammodon						? 1		
Bunomeryx								2
Oreodontidæ								—
Protoreodon								4
Protagriochœrus								1
Hyomeryx								1
Camelidæ aut Hypertragulidæ						—	—	—
Leptotragulus						?	×	3
Leptoreodon							×	1
Protylopus								1
Oromeryx								1

LOWER OLIGOCENE.

Chadron (White River group).

Titanotherium zone.

1. Chadron, South Dakota and adjoining parts of Nebraska and Wyoming.
2. Horsetail Creek, northeastern Colorado.
3. Pipestone Creek, Thompson Creek, and other localities in Montana.
4. Swift Current Creek, Canada.

	1.	2.	3.	4.
MARSUPIALIA.				
Didelphyidæ.				
Peratherium titanelix Matthew.			×	
CARNIVORA (CREODONTA).				
Hyænodontidæ.				
? Pseudopterodon minutus (Douglass)[a]			×	
Hemipsalodon grandis Cope				×
Hyænodon sp	×			
CARNIVORA (FISSIPEDIA).				
Canidæ.				
Daphænus dodgei Scott	×			
Daphænus sp	×		?	
Cynodictis paterculus Matthew			×	
Cynodictis sp	×			
? Cynodon sp	×			
Mustelidæ.				
Bunælurus infelix Matthew			×	
Felidæ.				
Dinictis fortis Adams	×			
Dinictis sp	×			
INSECTIVORA.				
Leptictidæ.				
Ictops acutidens Douglass			×	
Ictops thomsoni Matthew			×	
Ictops montanus Douglass			×	
Ictops intermedius Douglass			×	
Ictops tenuis Douglass			×	
Ictops major Douglass			×	
? Chrysochloridæ.				
Apternodus mediævus Matthew.			×	
Xenotherium unicum Douglass.			×	
Fam. indet.				
Micropternodus borealis Matthew			×	
RODENTIA.				
Sciuridæ.				
Prosciurus vetustus Matthew			×	
Prosciurus jeffersoni Douglass			×	
Castoridæ.				
Cylindrodon fontis Douglass			×	
Eutypomys sp.[b]				×

[a] The type of this species is at present indeterminate. The reference to *Pseudopterodon* is based on the specimen figured by Matthew, 1903.

[b] Auct. L. M. Lambe in lit.

LOWER OLIGOCENE—Continued.

	1.	2.	3.	4.
RODENTIA—Continued.				
ISCHYROMYIDÆ.				
Ischyromys veterior Matthew			×	
Gymnoptychus (=Adjidaumo) minutus (Douglass)			×	
Gymnoptychus (=Adjidaumo) minimus Matthew			×	
LEPORIDÆ.				
Palæolagus temnodon Douglass			×	
Palæolagus brachyodon Matthew			×	?
PERISSODACTYLA.				
HYRACODONTIDÆ.				
Hyracodon priscidens Lambe				×
Hyracodon sp	×		×	×
AMYNODONTIDÆ.				
Metamynodon sp	×			
RHINOCEROTIDÆ.				
Trigonias osborni	×			
Trigonias sp	×			
Leptaceratherium trigonodum	×			
Cænopus (=Subhyracodon) sp. div	×	×	×	
Cænopus cf. platycephalus O. and W.	×			
Cænopus mitis Cope	×	×		×
LOPHIODONTIDÆ.				
Colodon (=Mesotapirus) occidentalis Leidy	×		?	
EQUIDÆ.				
Mesohippus proteulophus Osborn	×			
Mesohippus hypostylus	×			
Mesohippus celer Marsh	×			
Mesohippus montanensis Osborn			×	
Mesohippus latidens Douglass			×	
Mesohippus precocidens Lambe				×
Mesohippus propinquus Lambe				×
Mesohippus stenolophus Lambe				×
Mesohippus planidens Lambe				×
Mesohippus assiniboiensis Lambe				×
Mesohippus ? brachystylus Osborn				×
? CHALICOTHERIIDÆ.				
"Chalicotherium" bilobatum Cope [a]				×
TITANOTHERIIDÆ (=BRONTOTHERIIDÆ).				
Titanotherium prouti Leidy	×			
Titanotherium heloceras (Cope)	×	×		
Titanotherium trigonoceras (Cope)	×	×		
Titanotherium ingens (Marsh)	×	×		
Megacerops coloradensis (Leidy)		×		
Megacerops dispar (Marsh)	×			
Megacerops angustigenis Cope				×
Megacerops selwynianus (Cope)				×
Megacerops tichoceras (S. and O.)	×			
Megacerops robustus (Marsh)	×			
Megacerops brachycephalus Osborn	×			

	1.	2.	3.	4.
PERISSODACTYLA—Continued.				
TITANOTHERIIDÆ (=BRONTOTHERIIDÆ)—continued.				
Megacerops bicornutus Osborn	×			
Megacerops marshi Osborn	×			
Allops serotinus Marsh	×			
Allops crassicornis Marsh	×			
Allops amplus (Marsh)	×			
Symborodon torvus Cope		×		
Symborodon acer Cope		×		
Symborodon montanus (Marsh)	×			
Brontotherium gigas Marsh		×		
Brontotherium curtum Marsh		×		
Brontotherium ramosum (Osborn)	×			
Brontotherium dolichoceras (S. and O.)	×			
Brontotherium platyceras (S. and O.)	×			
Brontotherium leidyi Osborn	×			
Brontotherium hypoceras (Cope)		×		
Brontotherium bucco (Cope)		×		
Titanotheriidæ indet			×	
ARTIODACTYLA.				
ELOTHERIIDÆ (=ENTELODONTIDÆ).				
Elotherium (=Entelodon) coarctatum Cope				×
Elotherium (=Entelodon) crassum Marsh	×	×		
Elotherium (=Entelodon) sp. div	×			
DICOTYLIDÆ (=TAGASSUIDÆ).				
Perchœrus sp	×			
LEPTOCHŒRIDÆ.				
Stibarus montanus Matthew			×	
ANTHRACOTHERIIDÆ.				
Hyopotamus (=Ancodon) americanus Leidy	×			
? Anthracotherium sp	×			
OREODONTIDÆ (=AGRIOCHŒRIDÆ).				
Bathygenys alpha Douglass			×	
Limnenetes platyceps Douglass			×	
? Limnenetes anceps Douglass			×	
Oreodon (=Merycoidodon) hybridus Leidy	×			
Oreodon (=Merycoidodon) affinis Leidy	×			
Oreodon (=Merycoidodon) bullatus Leidy	×			
Agriochœrus maximus Douglass			×	
Agriochœrus minimus Douglass			×	
Agriochœrus sp	×			
HYPERTRAGULIDÆ.				
Trigenicus socialis Douglass			×	
? Trigenicus mammifer Cope			?	×
Leptomeryx esulcatus Cope			?	×
Leptomeryx sp. div	×			
Heteromeryx dispar Matthew	×			
? Heteromeryx transversus (Cope)				×
CAMELIDÆ.				
? Leptotragulus profectus Matthew			×	

[a] Generic reference incorrect; family reference very questionable.

MIDDLE OLIGOCENE.

Brule (lower part) (White River group).

Oreodon zone.

1. Lower Brule, South Dakota and adjoining parts of Nebraska and Wyoming.
2. Cedar Creek, northeastern Colorado.
3. Scattered exposures in southwestern Montana.

	1.	2.	3.
MARSUPIALIA.			
Didelphyidæ.			
Peratherium fugax (Cope)	?	×	
Peratherium tricuspis (Cope)		×	
Peratherium huntii (Cope)		×	
Peratherium scalare (Cope)		×	
Peratherium marginale (Cope)		×	
Peratherium alternans (Cope)		×	
Peratherium pygmæum (Scott)		×	
CARNIVORA (CREODONTA).			
Hyænodontidæ.			
Hyænodon horridus Leidy	×	×	
Hyænodon cruentus Leidy	×	×	
Hyænodon crucians Leidy	×	×	
Hyænodon paucidens O. and W.	×		
Hyænodon leptocephalus S. and O.	×		
Hyænodon mustelinus Scott	×		
Hyænodon montanus Douglass			×
CARNIVORA (FISSIPEDIA).			
Canidæ.			
Daphœnus vetus Leidy	×	×	
Daphœnus hartshornianus (Cope)	×	×	
Daphœnus felinus Scott	×		
Daphœnus nebrascensis (Hatcher)[a]	×		
Daphœnus inflatus (Hatcher)	×		
Cynodictis gregarius (Cope)	×	×	
Cynodictis lippincottianus (Cope)	×	×	
Mustelidæ.			
Bunælurus lagophagus Cope		×	
? Oligobunis sp.	×		
Felidæ.			
Dinictis felina Leidy	×		
Dinictis squalidens (Cope)	×	×	
Dinictis paucidens Riggs	×		
Hoplophoneus primævus (Leidy)	×		
Hoplophoneus occidentalis (Leidy)	×		
Hoplophoneus oreodontis Cope	×	×	
Hoplophoneus sp. (transitional to Eusmilus)	×		
INSECTIVORA.			
Erinaceidæ.			
Proterix loomisi Matthew	×		
Leptictidæ.			
Leptictis haydeni Leidy	×		
Ictops dakotensis Leidy	×		
Ictops bullatus Matthew	×		
Ictops porcinus (Leidy)	×		
Mesodectes caniculus Cope		×	
Soricidæ.			
Protosorex crassus Scott	×		

	1.	2.	3.
INSECTIVORA—Continued.			
Talpidæ.			
Domnina gradata Cope		×	
Domnina crassigenis Cope		×	
? Geolabis rhynchæus Cope		×	
RODENTIA.			
Sciuridæ.			
Prosciurus relictus Cope		×	
Castoridæ.			
Eutypomys thomsoni Matthew	×		
Ischyromyidæ.			
Ischyromys typus Leidy	×		
Ischyromys cristatus (Cope)		×	
Gymnoptychus (=Adjidaumo) minutus Cope		×	
Gymnoptychus (=Adjidaumo) trilophus Cope		×	
Muridæ.			
Eumys elegans Leidy	×	×	
Leporidæ.			
Palæolagus haydeni Leidy	×	×	
Palæolagus turgidus Cope	×	×	
PERISSODACTYLA.			
Hyracodontidæ.			
Hyracodon nebrascensis Leidy	×		
Hyracodon arcidens Cope		×	
Hyracodon major S. and O.	×		
Amynodontidæ.			
Metamynodon planifrons S. and O.	×		
Rhinocerotidæ.			
Cænopus (=Subhyracodon) occidentalis Leidy	×	×	
Cænopus (=Subhyracodon) copei Osborn	×		
Cænopus (=Subhyracodon) simplicidens Cope	×		
Leptaceratherium trigonodum (O. and W.)	×		
"Hyracodon" planiceps S. and O.	×		
Anchisodon quadriplicatus Cope		×	
Lophiodontidæ.			
Colodon (=Mesotapirus) procuspidatus O. and W.	×		
Colodon (=Mesotapirus) dakotensis O. and W.	×		
Colodon (=Mesotapirus) cingulatus Douglass			×
Colodon (=Mesotapirus) longipes O. and W.	×		

[a] Mr. Hatcher regarded this and the following species as types of distinct genera. As all the distinctive characters are functions either of the size of the species or the wear of the teeth they can hardly be regarded as of generic importance. *D. nebrascensis* is in fact very closely related to *D. felinus* and *D. vetus*, and *D. inflatus* to *D. hartshornianus*.

MIDDLE OLIGOCENE—Continued.

	1.	2.	3.
PERISSODACTYLA—Con.			
TAPIRIDÆ.			
Protapirus simplex Wortman and Earle	×		
EQUIDÆ.			
Mesohippus bairdii Leidy	×	?	?
Mesohippus obliquidens Osborn	×		
Mesohippus eulophus Osborn		×	
Mesohippus exoletus (Cope)		×	
ARTIODACTYLA.			
ELOTHERIIDÆ (=ENTELODONTIDÆ).			
Elotherium (=Entelodon) mortoni (Leidy)	×	×	
Elotherium (=Entelodon) ingens Leidy	×		
Elotherium (=Entelodon) crassus Marsh	?	?	
Pelonax ramosus Cope[a]		×	
DICOTYLIDÆ (=TAGASSUIDÆ).			
Perchœrus probus Leidy	×		
Perchœrus nanus (Marsh)	×		
ANTHRACOTHERIIDÆ.			
Anthracotherium curtum (Marsh)	×		
Hyopotamus (=Ancodon) rostratus (Scott)	×		
LEPTOCHŒRIDÆ.[b]			
Leptochœrus spectabilis Leidy	×		
Leptochœrus lemurinus (Cope)		×	

	1.	2.	3.
ARTIODACTYLA—Con.			
LEPTOCHŒRIDÆ—continued.			
Leptochœrus robustus (Marsh)		×	
Leptochœrus gracilis Marsh	×		
Stibarus obtusilobus Cope		×	
Stibarus quadricuspis (Hatcher)	×		
OREODONTIDÆ (=AGRIOCHŒRIDÆ).			
Agriochœrus antiquus Leidy	×		
Agriochœrus latifrons Leidy	×		
Oreodon (=Merycoidodon) culbertsoni (Leidy)	×	×	
Oreodon (=Merycoidodon) gracilis Leidy	×	×	
Oreodon (=Merycoidodon) coloradensis Cope		×	
Oreodon (=Merycoidodon) periculorum Cope		×	
Oreodon (=Merycoidodon) macrorhinus Douglass			×
Oreodon (=Merycoidodon) sp. cf. bullatus Leidy	×		
Leptauchenia sp	×		
HYPERTRAGULIDÆ.			
Hypertragulus calcaratus Cope	×	×	
Hypertragulus sp. div	×		
Leptomeryx evansi Leidy	×	×	
Leptomeryx sp. div	×		
Hypisodus minimus Cope	×	×	
CAMELIDÆ.			
Poëbrotherium wilsoni Leidy	×	×	
Poëbrotherium labiatum Cope	×	×	
Poëbrotherium eximium Hay	×	×	
Paratylopus primævus Matthew	×		

UPPER OLIGOCENE.

FIRST PHASE—BRULE, UPPER PART (WHITE RIVER GROUP).

Protoceras and lower *Leptauchenia* zones.

1. Upper Brule, South Dakota and adjoining parts of Nebraska and Wyoming.
2. Lower Martin Canyon, Colorado.
3. White Buttes, North Dakota.[d]
4. Blacktail Deer Creek, Montana (?).[e]

SECOND PHASE—JOHN DAY.

Diceratherium and *Promerycochoerus* zones.

1. John Day, Oregon.[c]
2. ? Drummond, Montana.

	1.	2.	3.	4.	1. a.	1. b.	1. c.	2.
CARNIVORA (FISSIPEDIA).								
CANIDÆ.								
Paradaphænus cuspigerus (Cope)						?	?	
Paradaphænus transversus W. and M						?		
Nothocyon geismarianus (Cope)						×	×	
Nothocyon lemur (Cope)						×	×	
Nothocyon latidens (Cope)						×		
Cynodictis temnodon W. & M	×	×						
Cynodictis oregonensis Merriam						×		
Mesocyon coryphæus (Cope)						×	×	
Mesocyon josephi (Cope)						×	?	

[a] ? Upper Oligocene.
[b] This group may perhaps belong in Dichobunidæ.
[c] Chiefly auct. J. C. Merriam and W. J. Sinclair. The level of many species (marked "?") is doubtful as it is determined only by character of matrix. Where the level is unknown, it is given as between *b* and *c*, the lower beds of the formation being practically barren.
[d] Additional species from this region have been described by Douglass since the date of preparation of these lists. See Ann. Carnegie Mus., vol. 4, No. 2, 1907. The *Oreodon* horizon is also included in these exposures.
[e] More probably Lower Miocene.

UPPER OLIGOCENE—Continued.

	1.	2.	3.	4.	1. a.	1. b.	1. c.	2.
CARNIVORA (FISSIPEDIA)—Continued.								
CANIDÆ—Continued.								
Mesocyon drummondanus Douglass								×
Mesocyon brachyops Merriam							×	
Temnocyon altigenis Cope						×	×	
Temnocyon wallovianus Cope						?		
Temnocyon ferox Eyermann							×	
Philotrox condoni Merriam						×		
Enhydrocyon stenocephalus Cope						×	?	
Enhydrocyon basilatus Cope							?	
Enhydrocyon sectorius (Cope)							?	
MUSTELIDÆ.								
Oligobunis crassivultus [a] (Cope)							?	
Parictis primævus Scott						?		
FELIDÆ.								
Dinictis bombifrons Adams	×							
Dinictis cyclops Cope						?		
Nimravus gomphodus Cope						×	?	
Nimravus confertus Cope						?		
Nimravus debilis (Cope)						×	×	
Pogonodon platycopis (Cope)						×	?	
Pogonodon brachyops Cope							?	
Hoplophoneus davisi (Merriam)							×	
Hoplophoneus cerebralis Cope						×		
Hoplophoneus insolens Adams	×							
Eusmilus dakotensis Hatcher	×							
INSECTIVORA.								
TALPIDÆ.								
Proscalops miocænus Matthew		×						
RODENTIA.								
SCIURIDÆ.								
Prosciurus wortmani (Cope)						×		
Prosciurus ballovianus (Cope)						×		
CASTORIDÆ.								
Steneofiber nebrascensis (Leidy)	×							
Steneofiber peninsulatus Cope						×		
Steneofiber gradatus Cope						×	?	
Steneofiber complexus Douglass [b]								
Steneofiber hesperus Douglass				×				
GEOMYIDÆ.								
Entoptychus cavifrons Cope						×	?	
Entoptychus planifrons Cope						×	?	
Entoptychus minor Cope						×	?	
Entoptychus crassiramis Cope						×		
Entoptychus lambdoideus Cope							?	
Entoptychus sperryi Sinclair							×	
Entoptychus rostratus Sinclair							×	
Pleurolicus sulcifrons Cope						×		
Pleurolicus leptophrys Cope						×		
Pleurolicus diplophysus Cope						×		
APLODONTIIDÆ.								
Allomys nitens Marsh						×	?	
Allomys hippodus (Cope)							?	
Allomys multiplicatus (Cope)						×		
Allomys liolophus (Cope)						×		
Allomys cavatus (Cope)						×		
Mylagaulodon angulatus Sinclair							×	
MURIDÆ.								
Paciculus [c] lockingtonianus (Cope)						×		
Paciculus insolitus Cope						×		
Peromyscus nematodon (Cope)						×		
Peromyscus parvus Sinclair						×		

[a] See Matthew, Bull. Am. Mus. Nat. Hist., 1907, p. 193, for position of this genus.
[b] Madison Valley, Montana, ?*Protoceras* zone.
[c] Related to Dipodidæ auct. Scott.

UPPER OLIGOCENE—Continued.

	1.	2.	3.	4.	1. a.	1. b.	1. c.	2.
RODENTIA—Continued								
LEPORIDÆ.								
Palæolagus agapetillus Cope		×						
Palæolagus intermedius Matthew		×						
Lepus ennisianus Cope						×	×	
PERISSODACTYLA.								
HYRACODONTIDÆ.								
Hyracodon sp. div	×	×						
RHINOCEROTIDÆ.								
Cænopus tridactylus Osborn	×	?	×					
Cænopus platycephalus O. and W	×							
? Cænopus pacificus Leidy [a]						×		
? Cænopus truquianus Cope						×		
? Cænopus tubifer Cope						×		
? Cænopus annectens Marsh						×		
Diceratherium armatum Marsh						×		
Diceratherium nanum Marsh						×		
TAPIRIDÆ.								
Protapirus robustus Sinclair							×	
Protapirus obliquidens W. and E	×							
Protapirus validus Hatcher	×							
EQUIDÆ.								
Mesohippus intermedius O. and W	×							
Mesohippus meteulophus Osborn	×							
Mesohippus brachystylus Osborn	×							
Mesohippus acutidens Sinclair							×	
Mesohippus equiceps (Cope)						×	?	
Mesohippus brachylophus (Cope)						×		
Mesohippus longicristis (Cope)						×		
Miohippus anceps Marsh						×		
Miohippus annectens Marsh						×		
Miohippus condoni (Leidy)							×	
Miohippus validus Osborn	×							
Miohippus gidleyi Osborn	×							
Miohippus crassicuspis Osborn	×							
Anchitherium præstans Cope							×	
CHALICOTHERIIDÆ.								
Moropus ("Lophiodon") oregonensis Leidy							×	
Moropus senex Marsh						×		
Moropus distans Marsh						×	?	
ARTIODACTYLA.								
ELOTHERIIDÆ (=ENTELODONTIDÆ).								
Dæodon [b] shoshonensis Cope						×		
Boöchœrus humerosus Cope						×		
? Elotherium (=Entelodon) imperator Leidy							×	
? Elotherium (=Entelodon) calkinsi Sinclair							×	
Elotherium (=Entelodon) cf. ingens Leidy	×							
Elotherium (=Entelodon) ?crassus Marsh	×					×		
Elotherium (=Entelodon) bathrodon Marsh	×							
Elotherium (=Entelodon) sp	×				×			

[a] This and the three following species may be referable to *Diceratherium*.

[b] *Dæodon* Cope, 1878, *Boöchœrus* Cope, 1879, and *Dinohyus* Peterson, 1906, quite probably refer to one and the same genus, distinguished from *Elotherium* by slight development of chin bosses, moderate expansion of dependent processes of jugals, and certain minor changes in the premolars. *E. calkinsi* Sinclair belongs to this group, and perhaps other John Day species.

UPPER OLIGOCENE—Continued.

	1	2.	3.	4.	1. a.	1. b.	1. c.	2.
ARTIODACTYLA—Continued.								
DICOTYLIDÆ (=TAGASSUIDÆ).								
Perchœrus robustus (Marsh)	×					×		
Perchœrus pristinus (Leidy)						×	×	
Perchœrus socialis (Marsh)						×		
Perchœrus lentus (Marsh)						×		
Perchœrus subæquans (Cope)						×		
Perchœrus rostratus (Cope)						×		
Perchœrus trichænus (Cope)						×		
? Perchœrus platyops (Cope)	×							
Perchœrus osmonti (Sinclair)						×		
Chænohyus decedens Cope								
LEPTOCHŒRIDÆ.								
Leptochœrus sp	×							
ANTHRACOTHERIIDÆ.								
Anthracotherium karense O. and W	×							
Hyopotamus (=Ancodon) brachyrhynchus O. and W	×		?					
Arretotherium acridens Douglass				×				
OREODONTIDÆ (=AGRIOCHŒRIDÆ).								
Agriochœrus major Leidy	×							
Agriochœrus gaudryi (O. and W.)	×							
Agriochœrus migrans (Marsh)	×							
Agriochœrus ferox (Cope)						×		
Agriochœrus guyotianus (Cope)						×		
Agriochœrus ryderanus (Cope)						×		
Agriochœrus macrocephalus (Cope)						×		
Agriochœrus trifrons (Cope)						×		
Eporeodon (?=Eucrotaphus) occidentalis (Marsh)						×	?	
Eporeodon (?=Eucrotaphus) leptacanthus (Cope)						?	×	
Eporeodon (?=Eucrotaphus) pacificus (Cope)						×	?	
Eporeodon (?=Eucrotaphus) trigonocephalus (Cope)						×		
Eporeodon (?=Eucrotaphus) longifrons (Cope)						×		
Eporeodon (?=Eucrotaphus) major (Leidy)	×							
Eporeodon (?=Eucrotaphus) cedrensis Matthew		×						
Eporeodon (?=Eucrotaphus) socialis Marsh						×		
Eucrotaphus jacksoni Leidy	×							
Promerycochœrus superbus (Leidy)							×	
Promerycochœrus macrostegus (Cope)							×	
Promerycochœrus chelydra (Cope)							×	
Promerycochœrus leidyi (Bettany)							×	
Promerycochœrus minor Douglass								×
Leptauchenia sp	×							
HYPERTRAGULIDÆ.								
Hypertragulus hesperius Hay						×	×	
Hypertragulus planiceps (Sinclair)						×		
Leptomeryx sp. div	×							
Leptomeryx transmontanus Douglass								×
Protoceras celer Marsh	×							
Protoceras comptus Marsh	×							
Protoceras nasutus Marsh	×							
Calops cristatus Marsh	×							
Calops consors Marsh	×							
CAMELIDÆ.								
Paratylopus sternbergi (Cope)							×	
Paratylopus cameloides (Wortman)							×	
Pseudolabis dakotensis Matthew	×							
Camelidæ indet						×		

Range of Oligocene genera.

	Lower.	Middle.	Upper.	
			White River.	John Day.
MARSUPIALIA.				
Didelphyidæ				
Peratherium	1	7		
CARNIVORA (CREODONTA).				
Hyænodontidæ (Hyænodontinæ)				
Pseudopterodon	1			
Hemipsalodon	1			
Hyænodon	×	7		
CARNIVORA (FISSIPEDIA).				
Canidæ				
? Cynodon	×			
Daphœnus	1	5		
Cynodictis	1	2	1	1
Paradaphænus				2
Nothocyon				3
Mesocyon				4
Temnocyon				3
Philotrox				1
Enhydrocyon				3
Mustelidæ				
Bunælurus	1	1		
Oligobunis		?		1
Felidæ				
Dinictis	1	3	1	1
Pogonodon				3
Nimravus				3
Hoplophoneus		3		
Eusmilus			1	
INSECTIVORA.				
Leptictidæ				
Ictops	6	2		
Leptictis		1		
Mesodectes		1		
Erinaceidæ				
Proterix		1		
Soricidæ				
Protosorex		1		
Talpidæ				
Proscalops		3	1	
Chrysochloridæ				
Apternodus	2			
Xenotherium	1			
Fam. indet.:				
Micropternodus	1			
RODENTIA.				
Sciuridæ				
Prosciurus	2	1		2
Castoridæ				
Cylindrodon	1			
Eutypomys		1		
Steneofiber			3	2
Ischyromyidæ				
Ischyromys	1	2		
Gymnoptychus	2	2		
Geomyidæ				
Entoptychus				7
Pleurolicus				3
Aplodontiidæ				
Meniscomys				5
Mylagaulodon				1
Muridæ				
Eumys		1		
Paciculus				2
Peromyscus				2
Leporidæ				
Palæolagus	2	2	2	
Lepus				1

Range of Oligocene genera—Continued.

	Lower.	Middle.	Upper.	
			White River.	John Day.
PERISSODACTYLA.				
Hyracodontidæ				
Hyracodon	1	4	×	
Amynodontidæ				
Metamynodon	×	1		
Rhinocerotidæ				
Trigonias	1			
Leptaceratherium	1	1		
Cænopus	2	3	2	4
Diceratherium				2
Lophiodontidæ				
Colodon	1	5		
Tapiridæ				
Protapirus		1	2	1
Equidæ				
Mesohippus	11	4	3	4
Miohippus			3	3
Anchitherium				1
Chalicotheriidæ				
Moropus	?			3
Titanotheriidæ				
Titanotherium	4			
Megacerops [a]	12			
Brontotherium	3			
Symborodon	8			
ARTIODACTYLA.				
Elotheriidæ				
Elotherium [b]	1	4	3	5
Dicotylidæ				
Perchœrus	×	2	3	8
Chænohyus				1
Leptochœridæ				
Stibarus	1	2		
Leptochœrus		4	1	
Anthracotheriidæ				
Anthracotherium	×	1	1	
Hyopotamus	1	1	1	
? Arretotherium			1	
Oreodontidæ				
Bathygenys	1			
Oreodon	3	6		
Limnenetes	2			
Eporeodon			1	6
Promerycochœrus				5
Leptauchenia		1	1	
Agriochœrus	2	2	3	5
Hypertragulidæ				
Trigenicus	2			
Leptomeryx	1	1		1
Heteromeryx	2			
Protoceras			3	
Calops			2	
Hypertragulus		1		2
Hypisodus		1		
Camelidæ				
? Leptotragulus	1			
Paratylopus		1		2
Poëbrotherium		3		
Pseudolabis			1	

[a] Including *Allops*.
[b] Including *Pelonax*, *Dæodon*, and *Boöchœrus*.

LOWER MIOCENE.

Arikaree formation (in part).

Promerycochœrus zone.

First phase—Harrison.

1. Fort Logan, Montana.
2. Harrison, Nebraska.
3. Monroe Creek, Nebraska.
4. Lower Rosebud, South Dakota.
5. Canyon Ferry, Montana.

Second phase.

1. Laramie Peak, Wyoming.
2. Upper Harrison, Nebraska.
3. Upper Rosebud, South Dakota.
4. Uppermost Martin Canyon, Colorado.

CARNIVORA.

Canidæ.

First phase:

	1.	2.	3.	4.	5.
Nothocyon gregorii Matthew			X	X	
Nothocyon vulpinus Matthew				X	
Nothocyon annectens Peterson		X		X	
Nothocyon ? lemur Cope			X		
Cynodesmus thoöides Scott	X				
"Amphicyon" superbus Peterson		X			
Mesocyon robustus Matthew				X	
Mesocyon sp			X		
Enhydrocyon crassidens Matthew				X	

Second phase:

	1.	2.	3.	4.
Cynodesmus brachypus (Cope)	X			
Cynodesmus thomsoni Matthew			X	
Cynodesmus minor Matthew			X	

Procyonidæ.

Second phase:

	1.	2.	3.	4.
Phlaocyon leucosteus Matthew				X

Mustelidæ.

First phase:

	1.	2.	3.	4.	5.
? Brachypsalis simplicidens Peterson		X			

Second phase:

	1.	2.	3.	4.
Oligobunis lepidus Matthew			X	
Megalictis ferox Matthew			X	
Ælurocyon brevifacies Peterson		X		

Felidæ.

First phase:

	1.	2.	3.	4.	5.
Nimravus sectator Matthew				X	

INSECTIVORA.

Chrysochloridæ.

Second phase:

	1.	2.	3.	4.
Arctoryctes terrenus Matthew			X	

RODENTIA.

Castoridæ.

First phase:

	1.	2.	3.	4.	5.
Euhapsis brachyceps Peterson			X		
Euhapsis gaulodon Matthew				X	
Steneofiber ? pansus Cope				X	
Steneofiber fossor Peterson		X			
Steneofiber barbouri Peterson		X			
Steneofiber simplicidens Matthew				X	
Steneofiber sciuroides Matthew				X	
Steneofiber brachyceps Matthew				X	
Steneofiber montanus Scott	X				

Aplodontiidæ.

First phase:

	1.	2.	3.	4.	5.
Meniscomys sp		X		X	

Geomyidæ.

First phase:

	1.	2.	3.	4.	5.
Entoptychus formosus Matthew		?		X	
Entoptychus curtus Matthew				X	

Second phase:

	1.	2.	3.	4.
Entoptychus formosus Matthew			X	
Entoptychus curtus Matthew			X	

Heteromyidæ.

Second phase:

	1.	2.	3.	4.
Heteromyidæ indet			X	

LOWER MIOCENE—Continued.

RODENTIA—Continued.

LEPORIDÆ.

	1.	2.	3.	4.	5.		1.	2.	3.	4.
Lepus primigenius Matthew				×		Lepus macrocephalus Matthew			×	
Lepus macrocephalus Matthew				×						

PERISSODACTYLA.

RHINOCEROTIDÆ.

	1.	2.	3.	4.	5.		1.	2.	3.	4.
Diceratherium cooki Peterson		×				? Diceratherium sp			?	
Diceratherium niobrarense Peterson		×								
Diceratherium sp			×	×						

CHALICOTHERIIDÆ.

	1.	2.	3.	4.	5.		1.	2.	3.	4.
Moropus ? elatus Marsh		×				Moropus ? elatus Marsh		×		

EQUIDÆ.

	1.	2.	3.	4.	5.		1.	2.	3.	4.
Parahippus aff. crenidens Scott		×				Parahippus nebrascensis Peterson		×	×	
Parahippus sp				×		Parahippus sp			×	
Parahippus sp				×		Parahippus sp				×
Anchitherium sp				×						
"Miohippus annectens Marsh"	×									
'Miohippus equiceps Cope'	×									

ARTIODACTYLA.

ELOTHERIIDÆ (=ENTELODONTIDÆ).

	1.	2.	3.	4.	5.
Dinohyus hollandi Peterson		×			
Elotherium sp		×		×	

DICOTYLIDÆ (=TAGASSUIDÆ).

	1.	2.	3.	4.	5.		1.	2.	3.	4.
Desmathyus siouxensis (Peterson)		×				Desmathyus pinensis Matthew			×	
						Desmathyus sp		×		

OREODONTIDÆ (=AGRIOCHŒRIDÆ).

	1.	2.	3.	4.	5.		1.	2.	3.	4.
Mesoreodon chelonyx Scott	×					Merycochœrus proprius Leidy [a]	×			×
Mesoreodon intermedius Scott	×					Merycochœrus rusticus Leidy [b]				
Mesoreodon megalodon Peterson			×	×		Merycochœrus sp		×	×	
Mesoreodon ? latidens Douglass					×	Merychyus arenarum Cope	×			
Eporeodon sp. div				×		Merychyus leptorhynchus Cope	×			
Promerycochœrus carrikeri Peterson			×			Merychyus minimus Peterson		×		
Promerycochœrus vantasselensis Peterson		×				Merychyus sp			×	
Promerycochœrus sp. div				×						
Promerycochœrus hatcheri Douglass					×					
Promerycochœrus grandis Douglass					×					
Promerycochœrus hollandi Douglass					×					
Merycoides cursor Douglass					×					
Phenacocœlus typus Peterson			×							
"Merychyus elegans Leidy" [c]		×								
"Merychyus" harrisonensis Peterson		×		?						
Leptauchenia sp			×	×						
Leptauchenia decora Leidy				×						
Leptauchenia major Leidy				×						
Leptauchenia nitida Leidy				×						

[a] "Headwaters of Niobrara River, near Fort Laramie."
[b] Sweetwater River, Wyoming.
[c] Specific reference probably erroneous, generic reference of this and the following species doubtful The typical *Merychyus* is from the upper Miocene, the skull structure in the middle Miocene species is considerably more specialized than in any from the lower Miocene and although unknown in the upper Miocene species is presumably still more specialized. The species from this early phase of the lower Miocene have in general more brachydont molars, and it may prove necessary to separate them generically.

LOWER MIOCENE—Continued.

ARTIODACTYLA—Continued.

Camelidæ.

	1.	2.	3.	4.	5.
"Poëbrotherium sp."	×				
Stenomylus gracilis Peterson		×			

	1.	2.	3.	4.
Protomeryx halli Leidy			×	
Protomeryx ? cedrensis Matthew		×		
Protomeryx sp. div			×	
Oxydactylus longipes Peterson		×		
Oxydactylus brachyceps Peterson		×		

Hypertragulidæ.

	1.	2.	3.	4.	5.
Syndyoceras cooki Barbour		×			
Hypertragulus ordinatus Matthew					
Hypertragulus "calcaratus Cope"	×			×	

Antilocapridæ (Merycodontinæ).

	1.	2.	3.	4.
Blastomeryx advena Matthew			×	
Blastomeryx sp		×		

MIDDLE MIOCENE.

Deep River sequence.

Ticholeptus zone.

1. Deep River (Smith River), Montana.
2. Pawnee Creek, northeastern Colorado.
3. Flint Creek, Montana; ? North Boulder Creek, Montana, etc.
4. Mascall, Oregon.

	1.	2.	3.	4.
CARNIVORA.				
Canidæ.				
Tephrocyon rurestris Merriam				×
Cynarctus saxatilis Matthew		×		
Amphicyon sinapius Matthew		×		
"Canis" anceps Scott	×			
"Canis" cf. temerarius Leidy		×		
"Canis" sp		×		
Tomarctus brevirostris Cope		×		
?Cyon aut Icticyon sp		×		
??Aelurodon brachygnathus Douglass			×	
Mustelidæ.				
Mustela parviloba Cope		×		
Mustela ogygia Matthew		×		
Potamotherium lycopotamicum Cope				×
Felidæ.				
Pseudælurus ?intrepidus Leidy		×		
INSECTIVORA.				
Talpidæ.				
Talpa platybrachys Douglass			×	
RODENTIA.				
Sciuridæ.				
Sciurus sp			×	
RODENTIA—Continued.				
Mylagaulidæ.				
Mylagaulus lævis Matthew		×		
Mylagaulus paniensis Matthew		×		
Mesogaulus ballensis Riggs	×			
Ceratogaulus rhinocerus Matthew		×		
Geomyidæ.				
Geomys sp.[a]				
EDENTATA.				
? Megalonychidæ.				
Gen. innom. Sinclair				×
PROBOSCIDEA.				
Elephantidæ.				
Trilophodon (=Gomphotherium) proavus (Cope)		×		
Trilophodon (=Gomphotherium) breviceps (Cope)	×			
PERISSODACTYLA.				
Rhinocerotidæ.				
Cænopus persistens Osborn		×		
Aphelops megalodus Cope		×		
Aphelops profectus (Matthew)		×		
Aphelops planiceps Osborn		×		
? Aphelops oregonensis (Marsh)				×
? Aphelops sp			×	
Teleoceras medicornutus Osborn		×		

[a] Blue Creek, Nebraska, associated with *Cyclopidius*.

MIDDLE MIOCENE—Continued.

	1.	2.	3.	4.
PERISSODACTYLA—Con.				
TAPIRIDÆ.				
Tapiravus sp		×		
EQUIDÆ.				
Merychippus sejunctus (Cope)		×		
Merychippus labrosus (Cope)		×		
Merychippus isonesus (Cope)				×
Merychippus paniensis (Cope)		×		
Merychippus sphenodus (Cope)		×		
Merychippus seversus (Cope)				×
Merychippus campestris Gidley		×		
Hypohippus equinus Scott	×			
Hypohippus osborni Gidley		×		
Hypohippus sp		×		
Parahippus crenidens (Scott)	×			
Parahippus brevidens (Marsh)				×
Parahippus avus (Marsh)				×
Parahippus pawniensis Gidley		×		
Parahippus coloradensis Gidley		×		
Archæohippus ultimus (Cope)				×
Archæohippus sp. div				×
CHALICOTHERIIDÆ.				
Moropus sp		×		
ARTIODACTYLA.				
DICOTYLIDÆ (=TAGASSUIDÆ).				
Hesperhys vagrans Douglass			×	
OREODONTIDÆ (=AGRIOCHŒRIDÆ).				
Pronomotherium laticeps (Douglass)			×	
Merycochœrus cf. proprius Leidy		×		
Merycochœrus cf. rusticus Leidy		×		
Promerycochœrus montanus (Cope)	×			
?Promerycochœrus obliquidens (Cope)				×
ARTIODACTYLA—Con.				
OREODONTIDÆ (=AGRIOCHŒRIDÆ—Continued.				
Ticholeptus zygomaticus Cope	×			
Ticholeptus brachymelis Douglass			×	
Ticholeptus breviceps Douglass			×	
Ticholeptus bannackensis Douglass			×	
Poatrephes paludicola Douglass			×	
Mesoreodon longiceps Douglass			×	
Merychyus pariogonus Cope	×			
Merychyus smithi Douglass			×	
Merychyus sp. div		×		
Cyclopidius (=Pithecistes) decedens (Cope)	×			
Cyclopidius (= Pithecistes) emydinus Cope	×			
Cyclopidius (= Pithecistes) simus Cope	×			
Cyclopidius (= Pithecistes) incisivus Scott	×			
CAMELIDÆ.				
Miolabis transmontanus (Cope)				×
Protolabis longiceps sp. nov.[a]		×		
Protolabis heterodontus Cope		×		
Protolabis angustidens (Cope)		×		
Procamelus fissidens Cope		×		
Alticamelus altus (Marsh)		×		×
Alticamelus leptocolon sp. nov.[b]	?	×		
CERVIDÆ (PALÆOMERYCINÆ).				
Palæomeryx borealis Cope	×			
Palæomeryx antilopinus Scott	×			
Palæomeryx sp		×		×
Blastomeryx gemmifer Cope		×		
ANTILOCAPRIDÆ (MERYCODONTINÆ).				
Merycodus osborni Matthew		×		

UPPER MIOCENE AND ?LOWER PLIOCENE.

FIRST PHASE—ARIKAREE FORMATION (IN PART).

Procamelus zone.

1. Fort Niobrara ("Nebraska formation"), Nebraska.
2. Little White River, South Dakota.
3. Santa Fe, New Mexico.
4. Clarendon, Texas.
5. Madison Valley, Montana.

SECOND PHASE—OGALALLA FORMATION.

Peraceras zone (doubtfully separable).

1. Republican River, Kansas and Nebraska.
2. Archer, Florida (Alachua clays).
3. Rattlesnake, Oregon.

	First phase 1.	2.	3.	4.	5.	Second phase 1.	2.	3.
CARNIVORA.								
CANIDÆ.								
Ælurodon sævus (Leidy)	×	×				×		
Ælurodon haydeni (Leidy)	×	×			×			
Ælurodon wheelerianus (Cope)[c]			×			×		
? Ælurodon compressus Cope	×							
? ? Ælurodon hyænoides Cope	×							
Amphicyon americanus Wortman	?							
? Dinocyon ursinus (Cope)			×					
Dinocyon mæandrinus Hatcher						×		
Dinocyon gidleyi Matthew				×				
Dinocyon ossifragus Douglass					×			
"Canis" vafer Leidy	×							
"Canis" temerarius Leidy	×	?						
Ischyrocyon hyænodus Matthew		×						

[a] "*P. montanus* Douglass," Matthew, Mem. Am. Mus. Nat. Hist., vol. 1, pt. 7, 1901, p. 435, figs. 31–33. Not *P. montanus* of Douglass.
[b] "*Procamelus robustus* Leidy," Matthew, op. cit., p. 427, fig. 30. Not *P. robustus* of Leidy.
[c] Including *Æ. taxoides* Hatcher.

UPPER MIOCENE AND ? LOWER PLIOCENE—Continued.

	1.	2.	3.	4.	5.	1.	2.	3.
CARNIVORA—Continued.								
? PROCYONIDÆ.								
Leptarctus primus Leidy		Bijou Hills.						
MUSTELIDÆ.								
Mustela minor Douglass					×			
Putorius nambianus (Cope)			×					
Potamotherium robustum (Cope)	×							
Potamotherium lacota Matthew		×						
Lutra pristina Matthew		×						
Brachypsalis pachycephalus Cope	×							
FELIDÆ.								
"Machærodus" catocopis Cope						×		
? Machærodus maximus Scott & Osborn	?							
? Machærodus augustus Leidy	×							
? Machærodus crassidens Cragin						×		
Pseudælurus intrepidus Leidy	×							
RODENTIA.								
SCIURIDÆ.								
Sciurus arctomyoides Douglass					×			
Palæarctomys montanus Douglass					×			
Palæarctomys macrorhinus Douglass					×			
Palæarctomys vetus (Marsh)	?							
Cynomys sp						×		
CASTORIDÆ.								
Eucastor (=Dipoides) tortus Leidy	×	×				×		
Sigmogomphius lecontei Merriam						California		
MYLAGAULIDÆ.								
Mylagaulus sesquipedalis Cope						×		
Mylagaulus monodon Cope		×				×		
Mylagaulus pristinus Douglass					×			
Mylagaulus proximus Douglass					×			
Mylagaulus paniensis Matthew					×			
Epigaulus hatcheri Gidley						×		
GEOMYIDÆ.								
Geomys bisulcatus Marsh	?							
MURIDÆ.								
Hesperomys (=Peromyscus) loxodon (Cope)			×					
LEPORIDÆ.								
Panolax sanctæfidei Cope			×					
Lepus sp						×		
PROBOSCIDEA.								
ELEPHANTIDÆ.								
Trilophodon (=Gomphotherium) productus Cope			×	×				
Trilophodon (=Gomphotherium) euhypodon Cope						×		
Trilophodon (=Gomphotherium) campester Cope						×		
Trilophodon (=Gomphotherium) præcursor Cope				×				
Trilophodon (=Gomphotherium) floridanus Leidy							×	
PERISSODACTYLA.								
RHINOCEROTIDÆ.								
Teleoceras fossiger Cope		?				×	×	
Teleoceras crassus (Leidy)	×			×				
Teleoceras sp. div		×						
Peraceras superciliosus Cope						×		
? Aphelops malacorhinus Cope						×	×	
? Aphelops ceratorhinus Douglass					×			
? Aphelops jemezanus Cope			×					
? Aphelops brachyodus Osborn		×						
TAPIRIDÆ.								
Tapiravus rarus Marsh [a]								

[a] Recorded as coming from the "lower Pliocene, east of the Rocky Mountains."

UPPER MIOCENE AND ? LOWER PLIOCENE—Continued.

	1.	2.	3.	4.	5.	1.	2.	3.
PERISSODACTYLA—Continued.								
EQUIDÆ.								
Hypohippus affinis Leidy	×	×						
Hypohippus sp		×				×		
Parahippus cognatus Leidy	×							
Merychippus insignis Leidy	×							
Merychippus calamarius (Cope)			×					
Protohippus mirabilis Leidy	×							
Protohippus perditus Leidy	×	×						
Protohippus placidus Leidy	×	×						
Protohippus supremus Leidy	×	×						
Protohippus pernix (Marsh)	×							
Protohippus robustus (Marsh)	×							
? Protohippus parvulus (Marsh)	×							
Protohippus gracilis (Marsh)							Oregon Desert.	
Protohippus spectans (Cope)								×
Protohippus pachyops Cope				×				
Protohippus castilli Cope			Mexico.					
Protohippus profectus Cope						×		
Protohippus simus Gidley		×						
Protohippus fossulatus Cope				×				
Protohippus interpolatus Cope				×				
Neohipparion whitneyi Gidley		×						
Neohipparion occidentale (Leidy)		×						
Neohipparion speciosum (Leidy)			Bijou Hills.					
Neohipparion affine (Leidy)	×							
Neohipparion gratum (Leidy)	×							
Neohipparion calamarium (Cope)			×					
Neohipparion relictum (Cope)							Oregon Desert.	
Neohipparion montezumæ (Leidy)			Mexico.					
Neohipparion peninsulatum (Cope)			Mexico.					
Neohipparion lenticularis (Cope)				×				
Neohipparion dolichops Gidley		×						
Neohipparion niobrarense Gidley	×							
Neohipparion sinclairii Wortman								?
Neohipparion retrusum Cope						×		
Neohipparion princeps Leidy							Peace Cr., Fla.	
Neohipparion eurystylus (Cope)				×				
Neohipparion ingenuum (Leidy)							×	
Neohipparion rectidens (Cope)			Mexico.					
Neohipparion plicatile (Leidy)							×	
ARTIODACTYLA.								
DICOTYLIDÆ (=TAGASSUIDÆ).								
Prosthennops crassigenis Gidley		×						
Prosthennops serus (Cope)						×		
"Platygonus" striatus Marsh	?							
OREODONTIDÆ (=AGRIOCHŒRIDÆ).								
Pronomotherium altiramis Douglass					×			
? Merycochœrus cenopus Scott & Osborn	?							
? Merycochœrus sp						×		
Merychyus elegans Leidy	×							
? Merychyus medius Leidy	×							
? Merychyus major Leidy	×							
? Merychyus sp		×				×		
CAMELIDÆ.								
Procamelus occidentalis Leidy	×	×						
Procamelus robustus Leidy	×	×						
Procamelus gracilis Leidy	×		×					
? Procamelus prehensilis (Cope)						×		
Procamelus leptognathus Cope				×				
Procamelus major Leidy							×	
Procamelus minor Leidy							×	
Procamelus minimus Leidy							×	
Procamelus madisonius Douglass					×			
Procamelus lacustris Douglass					×			
Procamelus sp. div				×		×		
Protolabis montanus Douglass					×			
Protolabis serus (Douglass)					×			
Pliauchenia humphreysiana Cope			×					
Pliauchenia sp		×						
Pliauchenia vera sp. nov.[a]						×		
Pliauchenia minima Wortman						×		
Pliauchenia sp. max				×		×		

[a] "*Pliauchenia humphreysiana* Cope," Wortman, 1899, not of Cope. Jaw larger, more robust premolars more reduced, p. 2 absent, while in *P. humphresiana* it is vestigial.

UPPER MIOCENE AND ?LOWER PLIOCENE—Continued.

	1.	2.	3.	4.	5.	1.	2.	3.
ARTIODACTYLA—Continued.								
CERVIDÆ.								
Palæomeryx americanus Douglass					×			
Palæomeryx teres (Cope)			×					
Palæomeryx trilateralis (Cope)			×					
Palæomeryx sp. div		×						
Blastomeryx wellsi Matthew		×						
ANTILOCAPRIDÆ (MERYCODONTINÆ).								
Merycodus necatus Leidy	×							
Merycodus furcatus (Leidy)	×							
Merycodus ramosus (Cope)	×							
Merycodus agilis Douglass					×			
? ? Merycodus tehuanus (Cope)			×					

Range of Miocene genera.

[The figures show the number of described species in each genus. Crosses indicate that the presence of the genus is recorded, but no species have been described.]

	Lower.		Middle.	Upper.	
	Lower Rosebud.	Upper Rosebud.		"Nebraska."	"Republican River."
CARNIVORA.					
Canidæ					
Nothocyon	4				
Cynodesmus	1	3			
Mesocyon	2				
"Canis"			?	2	×
Cynarctus			1		
Tomarctus			1		
Amphicyon	? 1		1	? 1	
Dinocyon				3	1
Ischyrocyon				1	
Enhydrocyon	1				
? Cyon			?		
Tephrocyon			1		
Aelurodon			?	5	2
Procyonidæ					
Phlaocyon		1			
Leptarctus				1	
Mustelidæ					
Oligobunis		1			
Aelurocyon		1			
Megalictis		1			
Potamotherium			?	2	
Brachypsalis	?			1	
Lutra				1	
Mustela			2	1	
Putorius				1	
Felidæ					
Nimravus	1				
Pseudælurus			1	1	
"Machærodus"				3	1
INSECTIVORA.					
Chrysochloridæ					
Arctoryctes		1			
Talpidæ					
Talpa			1		
RODENTIA.					
Sciuridæ					
Sciurus			×	1	
Palæarctomys				3	
Cynomys					?
Castoridæ					
Euhapsis	2				
Steneofiber	7				
Eucastor (=Dipoides)				1	1

Range of Miocene genera—Continued.

	Lower.		Middle.	Upper.	
	Lower Rosebud.	Upper Rosebud.		"Nebraska."	"Republican River."
RODENTIA—continued.					
Mylagaulidæ					
Mylagaulus			2	4	2
Ceratogaulus			1		
Mesogaulus			1		
Epigaulus					1
Geomyidæ					
Entoptychus	2	2			
? Geomys				1	
? Thomomys			×		
Muridæ					
? Hesperomys (= Peromyscus)				1	
Aplodontiidæ					
Meniscomys	×				
Heteromyidæ					
Heteromyid indet		×			
Leporidæ					
Lepus	1	1		×	×
Panolax				1	
EDENTATA.					
Megalonychidæ:					
Gen. innom			?		
PROBOSCIDEA.					
Elephantidæ					
Trilophodon (= Gomphotherium)			2	2	3
PERISSODACTYLA.					
Rhinocerotidæ					
Diceratherium	2	?			
Cænopus			1		
Aphelops		?	4	3	1
Teleoceras			1	2	1
Peraceras					1
Tapiridæ					
Tapiravus			×	×	
Equidæ					
Anchitherium	×				
Archæohippus			1		
Hypohippus			2	1	×
Parahippus	3	3	5	1	
Merychippus			7	2	
Protohippus (incl. Pliohippus)				12	3
Neohipparion				12	6
Chalicotheriidæ					
Moropus	1	×	×		
ARTIODACTYLA.					
Elotheriidæ (= Entelodontidæ)					
Elotherium (= Entelodon)	?				
Dinohyus	1				
Dicotylidæ (= Tagassuidæ)					
Desmathyus	1	1			
Prosthennops				1	1
Hesperhys			1		
Oreodontidæ (= Agriochœridæ)					
Eporeodon	×				
Mesoreodon	4		1		
Phenacocœlus	1				
Merycoides	1				
Merychyus	3	3	2	3	×
Ticholeptus (incl. Poatrephes)			5		
Promerycochœrus	5		2	1	
Merycochœrus		2	2	?	?
Pronomotherium			1	1	
Leptauchenia	3				
Cyclopidius			4		

Range of Miocene genera—Continued.

	Lower.		Middle.	Upper.	
	Lower Rosebud.	Upper Rosebud.		"Nebraska."	"Republican River."
ARTIODACTYLA—continued.					
Camelidæ					
Protomeryx	....	2			
Oxydactylus	....	2			
Miolabis	....	....	1		
Protolabis	....	....	3	2	
Alticamelus	....	....	2	?	1
Procamelus	....	....	?	6	4
Pliauchenia	....	....	....	1	3
? Stenomylus	1				
Hypertragulidæ (incl. Protoceratidæ)					
Syndyoceras	1				
Hypertragulus	2				
Cervidæ					
Palæomeryx	....	....	2	3	
Blastomeryx	....	1	1	1	
Antilocapridæ (Merycodontinæ)					
Merycodus	....	....	1	6	×

MIDDLE PLIOCENE.

Blanco formation (Texas).

Glyptotherium zone.

CARNIVORA.

Canidæ.

Borophagus diversidens Cope.
? Amphicyon sp.

Mustelidæ.

Canimartes cumminsi Cope.

Felidæ.

Felis hillanus Cope.

EDENTATA.

Glyptodontidæ.

Glyptotherium texanum Osborn.

Megalonychidæ.

Megalonyx leptostoma Cope.

Mylodontidæ.

Mylodon sp.

PROBOSCIDEA.

Elephantidæ.

Trilophodon (=Gomphotherium) shepardii Leidy.[a]
Dibelodon mirificus Leidy.
Dibelodon tropicus Cope.
Dibelodon præcursor Cope.
? Dibelodon humboldtii (Cuvier).

PERISSODACTYLA.

Equidæ.

Pliohippus simplicidens (Cope).
Protohippus minutus (Cope) (=phlegon (Hay)).
Protohippus cumminsii (Cope).
Neohipparion sp.

ARTIODACTYLA.

Dicotylidæ (=Tagassuidæ).

Platygonus bicalcaratus Cope.
Platygonus texanus Gidley.

Camelidæ.

Pliauchenia spatula Cope.
Pliauchenia sp.

[a] This species should probably be referred to *Dibelodon*.

INDEX.

O